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Three-Dimensional Motion Picture Applications

By R. V. Bernier

Images on the retinae of the eyes, resulting when viewing real life subject matter, are not in themselves three-dimensional. The impulses from these images which travel to the brain supply the brain with the data it needs to build the three-dimensional vision which the observer sees in lieu of the subject itself. Present grainless motion picture color film is a nearly perfect medium of establishing synthetic images on the retinae which equal the natural ones. As a result, the data that reaches the brain is comparable to that which might emanate from natural images. The brain, detecting little difference, forms a synthetic vision nearly as perfect as natural vision.

The three-dimensional motion picture camera has been employed with success to capture all of the components of depth perception which are associated with natural vision. In addition high-speed and time-lapse applications have been developed which also incorporate factors of depth perception otherwise impossible to duplicate in natural vision.

A solution of the flicker problem in 16-mm, alternate-frame, stereo projection at 24 frames/sec has been provided through the use of the Morgana shuttle movement. Also the requirement for registration adjustments before or during projection has been eliminated by the use of a barrel-type polarizer which permits projecting through a single-lens axis.

The trend indicates that eventually methods for imaging, transmitting or preserving and re-presenting subject matter will approach a state of perfection. This state of perfection will provide a synthetic vision of the subject which will be difficult to detect from reality. Three-dimensional motion pictures are a step in this direction, as is also three-dimensional television, although it is still more experimental.

Much has been accomplished on three-dimensional taking and projecting equipment and on the general problems involved. Noteworthy is the work of H. E. Ives,[1] who pioneered the composite or lenticulated system, E. H. Land,[2] who invented Polaroid and thus simplified the problem of projection, and J. A. Norling.[3] The first commercial application of Polaroid to a three-dimensional picture is credited to Norling who produced and exhibited a 35-mm black-and-white motion picture

Presented on May 2, 1951, at the Society's Convention at New York, by Maj. R. V. Bernier, U.S.A.F., Stereo and Photomicrographic Unit, Instrumentation and Analysis Section, AMC Photo Service Center, Wright-Patterson Air Force Base, Dayton, Ohio.

at the New York Worlds Fair in 1939. Previous three-dimensional pictures requiring red and green viewing devices and subsequent three-dimensional films produced by Norling have made him in the author's opinion a well qualified authority on the subject. In his papers which he presented at the fall meeting of the SMPE at New York in 1939, and at the spring meeting at Rochester in 1941, he discussed thoroughly this subject of three-dimensional motion pictures. In view of this and other published literature on the subject this paper will be confined to a brief discussion of the synthesis of vision, followed by a discussion of the equipment and principles involved.

Synthetic Vision

Both motion pictures and television are excellent mediums for portraying subject matter in a real and lifelike manner. Their three-dimensional possibilities cannot be fully appreciated until the synthesis of natural vision is examined and understood.

When we look at a subject or scene, rays of light therefrom enter the displaced pupils of each of our two eyes and form real images on the retinae. It is true that these images are slightly different because they were formed from different viewpoints, and it is also true that this difference is an extremely important factor. Even though this fact is considered, these images are not so unusual. It is the three-dimensional vision formed by the brain which is really unusual and really miraculous. The brain forms this remarkable vision by compiling the millions of electrochemical impulses being generated at the retinae and arriving through the medium of the optic nerves. This fact indicates that if the natural retinal images could be exactly duplicated synthetically there would be no change in the character of the impulses being generated. Thus, the brain would form the same remarkable three-dimensional vision. It is evident from the foregoing that in natural vision we do not see the actual subject itself, we see a vision of it as set up by the brain.

To create synthetic vision, which could be, and eventually will be almost as remarkable as natural vision, we need to deal only with the retinal images. The impulses and resultant true three-dimensional vision will occur automatically once we have supplied faultless images. The natural retinal images were described above as not unusual, the implication being that they are not in themselves three-dimensional. Other than lying in a spherical plane they are quite analogous to a good photographic lens image. This suggests that they could be duplicated in the focal plane of a twin-lens camera. The problem rests simply in transporting them from these focal planes to the retinae, intact, that is to say, without loss of resolution, color quality, etc. When this is accomplished and faultless synthetic images are supplied to the retinae, it will, for example, be quite possible to stand in the middle of the Mojave Desert and actually feel that we are physically at Palm Springs. This sensation of realness is nearly natural today, especially when high-quality motion picture films and the correct viewing conditions are employed as the medium of transporting the images from the twin-lens camera focal plane to the retinae.

Further improvements in the naturalness of synthetic vision depend for the most part on improvements in the transporting medium whether it be motion picture films, television, or both, these being the only mediums to date which can adequately capture all of the factors of depth perception.

Factors of Depth Perception

All factors of depth perception must be present if we wish synthetic vision to equal natural vision. These factors are:

1. Light and shadow
2. Perspective
3. Color
4. Focus reaction
5. Movement of the viewpoint
6. Stereoscopic vision

Only the first two of these factors are incorporated in a black-and-white paper print, and only the first three are present in a color transparency.

The fourth factor, focus reaction, needs some explanation. It is the reaction which assists us in estimating the relative positions, in space, of near objects. The physical change required of the eye lens to bring objects at different distances into sharp focus helps to advise us as to their actual distances from our viewpoint. This function of the human eyes is noticeably active only for objects closer than 6 or 7 ft. There is a decreasing degree of activity beyond this distance up to a maximum of 20 ft (optical infinity), but the reaction is so slight that it can be considered negligible.

The process of projection, or the process of viewing a print or transparency through a lens, in effect incorporates the focus reaction factor. That is partly the reason why these processes can cause subject matter to appear more lifelike. Actually in this case focus reaction is not activated. On the other hand, the fact that the flat plane of the image is projected beyond a point where focus reaction might be activated precludes, by the absence of the reaction, the opportunity to detect the lack of plasticity. In other words, the focus-reaction factor cannot assist in detecting that the screen image is flat unless the latter lies less than 6 or 7 ft from our viewpoint.

Two factors of depth perception do remain, however, and they can be employed by the observer to detect the presence or absence of solidity in a projected image.

The first of these, and a very important factor, is "movement of the viewpoint." When we are looking at a physical scene and choose to move our viewpoint laterally, subject matter in the foreground will appear to move further and will pass in front of the subject matter in the background. This phenomenon would not occur of course if we were looking at a single projected transparency and chose to move our viewpoint. The absence of this effect in this case would also betray the lack of solidity in the projected image.

The last factor, stereoscopic vision, surveys by triangulation the exact position of objects in respect to the eye base or viewpoint. This feature would also betray that all objects, being portrayed by the single image on the screen, were flat and were located in the plane of the screen. This is true, providing of course that the projection distance is not beyond the limit of our ability to triangulate, a distance generally conceded to be about one fourth of a mile. An interesting condition exists with the single lens pocket viewer. In this case the flatness of the image cannot possibly be detected, either by focus reaction since the image appears at infinity, or by stereoscopic triangulation since the second "station" needed to triangulate objects is precluded from use.

The Superior Medium

A full-color three-dimensional motion picture is superior to any other existing medium of synthetic vision. It is most capable of transporting the real moving images from the focal plane of the twin-lens camera to the retinae of the human eyes. The movement phenomenon previously discussed, which we unconsciously but always associate with natural vision when we ourselves move, can easily be incorporated by rotating the subject in front of the camera, or by moving the camera on a dolly or

boom toward, around, and/or over the subject.

Present grainless color film available to the industry can and does capture the stereo focal-plane images nearly unimpaired. Very little of the original aerial image quality is lost. In addition motion picture color film is capable of recording and transmitting to the retinae all factors of depth perception inherent in the original stereo focal-plane images.

Television Application

Considering the rapid progress being made in television, it also may soon provide a medium of synthetic vision comparable to natural vision. Curiously enough the mechanics of obtaining ortho-stereoscopic results in television are relatively simple. For example, the receiving end could consist of a small rectangular picture tube receiving the two required views side by side. The over-all dimensions of the tube face should be approximately 6 × 13 cm. For ortho-stereoscopic viewing this miniature tube should be encased in a small hand-held stereoscope-like viewer. This viewer would be equipped with twin 80-mm focal length, 35-mm diameter plano convex lenses, a "window" mask format, and a cable to connect it to a master receiver. The taking camera could be equipped with either twin lenses or a beam splitter attachment. In either case the stereo pair of images would be picked up side by side on the camera tube and transmitted in the usual manner.

ALTERNATE-FRAME TECHNIQUE

Obviously 35-mm motion picture film is superior to 16-mm in ultimate screen quality. Also it is evident that the success of future entertainment three-dimensional films, if and when they make their debut, is dependent not only on the appeal that this added feature might have, but also dependent on the quality of the screen image. Therefore present quality standards will have to be maintained or even improved upon.

To be sure, there are applications of the three-dimensional motion picture other than for entertainment purposes. These are principally in the fields of education, industry and science. In those fields portability of equipment and low production cost are prerequisites to the use of such films, and so 16-mm film seems to be the right answer.

The question is which of the known systems of 16-mm three-dimensional motion pictures is going to fulfill the rather strict requirements.

The author realizes that each system has its advantages and disadvantages, and that eventually one of these systems may prove superior to the others. In view of this, work is in progress now in connection with the development of a "split-frame" technique. The purpose is to compare all phases of its operation and results with the alternate-frame technique. Because the film presented with this paper was of the alternate-frame type and because of limitations placed on this paper, the following discussion will be confined to this system exclusively.

The original decision to concentrate effort on improvements in the alternate-frame technique was based on the possible advantages which could be had by maintaining full-frame standards and at the same time confining at least the projection to a single standard film. Figure 1 shows a sample strip of alternate-frame stereo film. On projection the right eye will see every alternate frame, the left eye will see those in between. Note the difference in position of objects on adjacent frames with respect to each other and to the edge of the film.

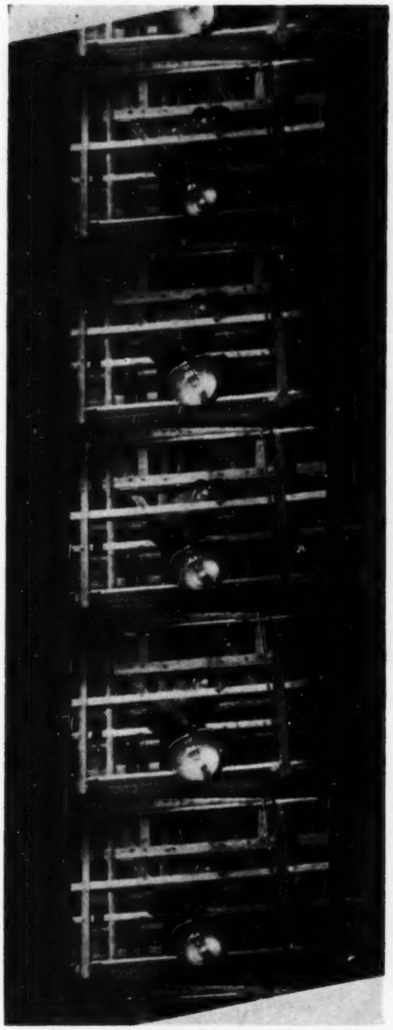

Fig. 1. Section of 16-mm alternate-frame stereo film.

Projection

The projection requirements for alternate-frame film are substantially the same as they are for stereo film of other systems. The right- and left-eye images must be registered properly on the screen and must be selectively polarized for their respective eyes. It has been the practice to use the same type of attachment on the projector that was used on the camera. Such an attachment, a beam splitter with synchronized shutter was tested prior to the development of the present adapter. The latter was developed in an attempt to eliminate the screen registration problems characteristic of the beam splitter attachment. Figures 2a and 2b show the principle of its operation. Figure 2a shows the Polaroid filter 16 which is semicylindrical and positioned to be rotated on its axis in the same plane as, but normal to, the lens axis. Polarization 20 of the filter when viewed from the lens position is 45° upward and to the left. A frame 22 having a left stereoscopic image therein is centered on the lens axis. The image 24 on the screen 18 may be seen with the left eye only by a viewer wearing standard Polaroid spectacles. In Fig. 2b, the film 12 has been advanced so that a frame 26 having a right stereoscopic image thereon is centered on the lens axis while the filter 16 has been revolved 180° from the position it occupied in Fig. 2a. It may be noted in Fig. 2a that the outside of the semicylindrical filter 16 is presented to the lens 14, while in Fig. 2b the inside of

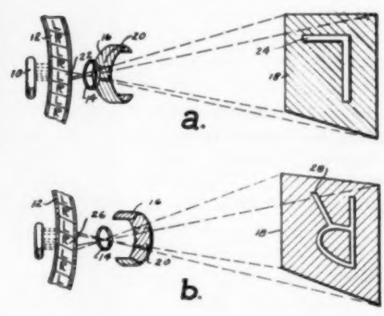

Fig. 2. Barrel polarizer principle of alternately and selectively polarizing right and left screen images.

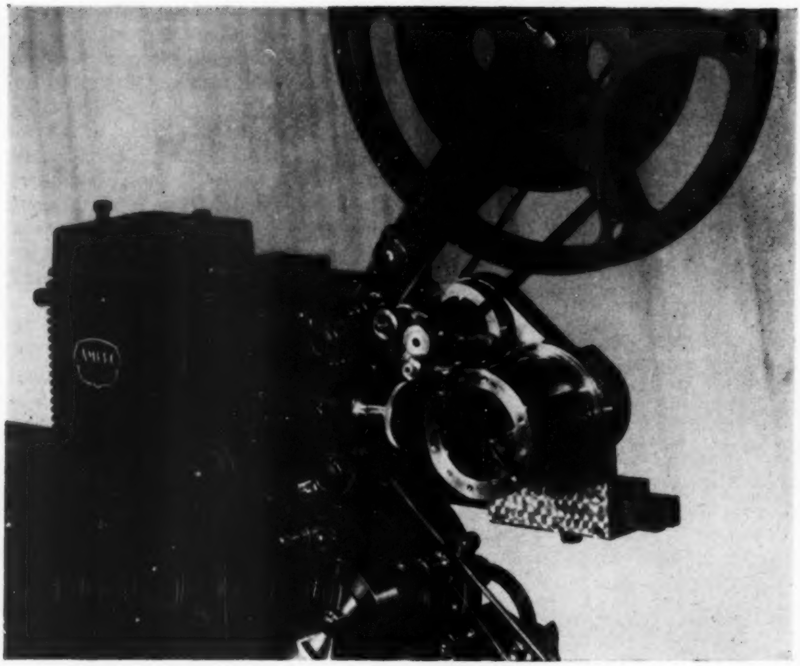

Fig. 3. Film-driven barrel polarizer attachment.

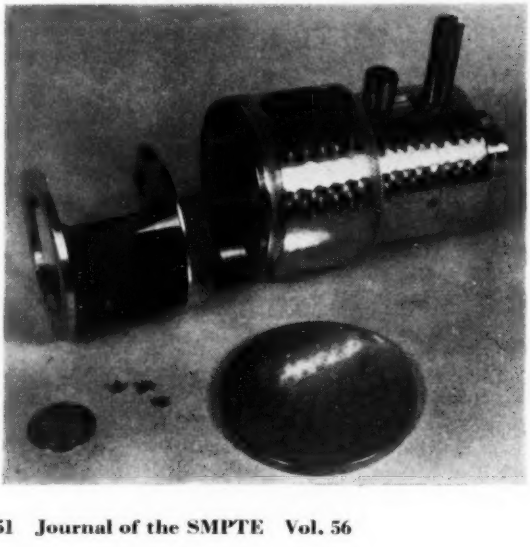

Fig. 4. Direct-drive polarizer attachment showing barrel and mounted Polaroid filter.

the semicylindrical filter is presented to the lens 14. Moreover, the same axis 20 of polarization which, in Fig. 2a, extended upwardly and to the left, now extends upwardly and to the right. Thus the image 28 on the screen 18 may be seen with the right eye only by a viewer wearing standard Polaroid spectacles.

Three stages of evolution of the barrel-type polarizer attachment[4] were: (1) a barrel driven through a gear train by power transmitted by the film itself (see Fig. 3); (2) the same attachment geared to operate at three times its original speed so that it could be used on a projector incorporating the Morgana[5] shuttle movement; and (3) an entirely new gear housing driving the same type of barrel polarizer through a direct power shaft on the projector (see Fig. 4).

Referring to Fig. 3 again, it will be noted that the film is threaded through a sprocket drive on the attachment. The latter has no other power connections to the projector. This attachment was first designed so that it could be used on almost any 16-mm projector. The movement of the film through the sprocket drive was sufficient to keep the polarizer in synchronization with its movement through the film gate. An adjustment knob on the attachment provided for changing the position of the drive sprocket with respect to the power sprocket on the projector. The increase or decrease in distance, by one frame length, between the two sprockets, served to synchronize the rotating polarizer with right or left frames, at will, during projection. This was necessary to compensate for discrepancies in the right–left–right, etc., sequence in the film due to threading or splicing errors.

As predicted, the flicker at 24 frames/sec was considerable. Increasing the speed of projection to 36 frames/sec helped somewhat but it was soon realized that some other approach to the problem would be necessary. The Morgana[5] shuttle movement proved to be the solution to the flicker problem. The Morgana movement was designed to eliminate the same sort of flicker in the two-color process. A search uncovered the existence of one of these mechanisms at the Bell & Howell plant in Chicago. It was procured and mounted on a Bell & Howell Showmaster chassis. The first polarizer attachment (Fig. 3) was then regeared to revolve at three times its former speed so as to correspond to the new framing speed of the Morgana movement. Previously while one eye was getting the benefit of three "flicks" the other had to wait through a period of $^1/_{24}$ sec. Now with the Morgana movement the fluctuation of light, with respect to either eye, was uniform. The system which involves shuttling one frame backwards for every two forward, facilitates progression of the film through the projector at standard sound speed, and at the same time provides a flicker frequency of 72 frames/sec, or 36 frames/sec per eye.

Figure 5 shows the final product in the evolution of the barrel polarizer. Here it is shown attached to the Bell & Howell Showmaster projector which in turn is equipped with a Morgana movement. The polarizer in this case is powered through its gear train directly by the gear mechanism of the projector and not by the film. This change was found to be necessary due to the inability of the film-driven model to stay in exact synchronization at the higher speed required with the Morgana movement.

Characteristics of the Alternate-Frame Principle

The alternate-frame principle offers certain advantages over the split-image system. Both the right-eye image and the left-eye image occupy standard full frames on the film. This feature provides for maintaining the

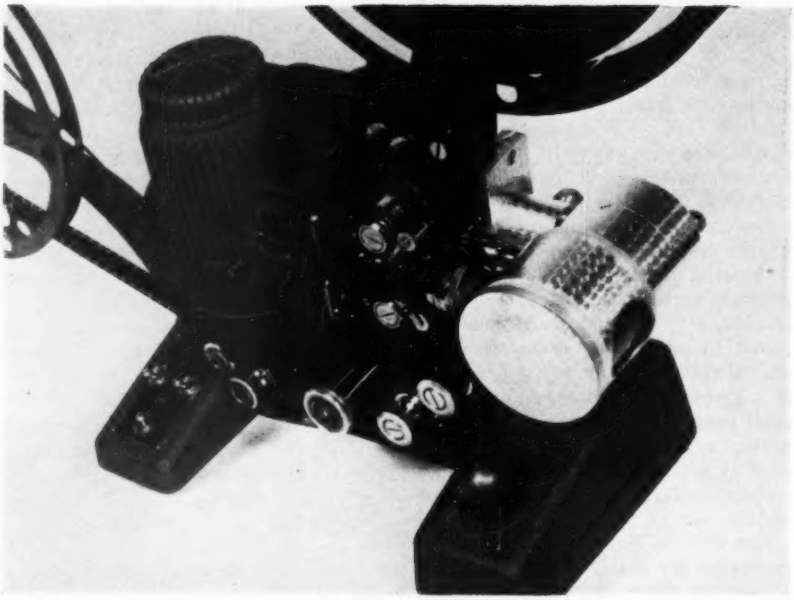

Fig. 5. Direct-drive polarizer attachment mounted on Bell & Howell Showmaster Projector. This projector is equipped with the Morgana movement.

quality standard for 16-mm projection. The alternate-frame principle also facilitates projection through a single undisplaced axis from the projector aperture straight to the screen. Because of this feature there is no need to register manually the two images on the screen. Registration, on the other hand, is accomplished during filming or during processing and is accurately maintained in the film gate aperture of the projector and likewise on the screen. Effects, which should result from calculated lateral image displacement, are faithfully reproduced on the screen. In contrast the usual type of beam splitter displaces the axis of the images, and reregisters the stereo images separately. As a result the effects intended at the time of the photography are seldom accurately reproduced on the screen. In addition, and because of projectionists' errors, vibrations, etc., the beam splitter system can be the cause of misregistration which in turn results in eyestrain. Unfortunately, many believe, unjustly, that such eyestrain is characteristic of any and all three-dimensional pictures.

Although the Morgana movement accomplished wonders in solving the flicker problem, it introduced a limitation in the allowable rate of action of moving objects. Any fast subject movement, especially laterally, appears considerably jumpy on the screen. The reverse shuttling feature of the Morgana movement, of course, is directly responsible. To be sure, this new bug is troublesome, but it is not nearly as detrimental as was the flicker condition.

PRODUCING THE ALTERNATE-FRAME STEREO FILM

Single-axis projection, as described in the preceding section, requires that the registration and/or image displacement problem be considered and dealt with during the making of the film. To accomplish this properly certain practices must be adhered to.

Referring to the diagram, Fig. 6, L and R represent the left and right viewpoints of the taking camera. If two cameras are used, L and R represent the optical center of the left and right camera lenses respectively. (The frames of the two films in this case are printed alternately by a special effects printer on a single positive film.) If one camera with a beam splitter is used, L and R represent the optical centers of the optically split and displaced lens. The distance between the two optical centers is the interocular. The field coverage of the left lens is the cone bounded by the two lines XL and YL. The common plane XY, where the cone of coverage of each lens is coincident, is the datum plane. It represents the position in space where objects photographed, and projected, appear to lie in the plane of the projection screen. The reason for their appearing to lie in the screen plane is simply that there exists no lateral displacement between their left and right images on the film. Thus they exactly superimpose on the screen and our eyes "triangulate" them in that position.

[The position of the datum plane, as can be seen by the diagram, is fixed always at the point where the axis of Lens L intersects with the axis of Lens R.] The distance between the datum plane and the camera lenses is the convergence distance. The convergence angle is the angle between the axis of the two lenses. The far image displacement distance (D) is the distance at the datum plane between rays, entering lens L and lens R, which have

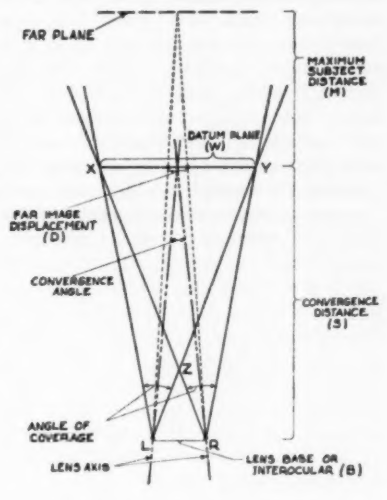

Fig. 6. Diagram of factors involved in alternate-frame stereo motion picture photography.

emanated from a point on the farthest object within the field of coverage.

Under certain conditions the distance to the farthest object must be limited, as for example when shooting close-ups or when using an interocular greater than the normal interpupillary distance $2\frac{1}{2}$ in. Assuming a maximum projection screen width of 70 in. and a maximum projection distance of 30 ft, (D) should not exceed more than $^1/_{28}$ the total width of the datum plane XY. This is calculated from the maximum image displacement allowance on the screen of $2\frac{1}{2}$ in. divided into 70 in. or the screen width. It can be seen that under close-up conditions, some type of limiting plane or backdrop must be used. The distance to this plane, or to infinity when the photographic conditions are normal, is the maximum subject distance (see Fig. 6).

Effects and Rules

The true size, shape, position and relation to one another, of objects in space can exist only when the lens base equals the average eye base, the convergence distance equals the intended viewing distance and the distance XY equals the screen size. Obviously this implies that there can be only one correct viewing position. In practice, however, the area of good viewing positions is comparable to the viewing conditions associated with two-dimensional projection. Distortion in depth is noticeable in extreme positions but there seems to be little that can be done about it except to move to a better position. Positions closer to the screen cause the depth dimension to be compressed, positions further from the screen cause the depth to be elongated. It can be seen from the foregoing that in 16-mm work where conditions of projection are relatively stable, i.e., 2-in. lens projecting from 20 to 25 ft onto a 45 × 60 in. screen, that normally the camera conditions could be fixed. This would simply require 2-in. lenses 2½ in. apart converged on a point 25 ft from the camera. These conditions then would permit shooting any subject that might lie all within the space XYZ Fig. 6, or all or parts of which might lie beyond the datum plane. In projection, assuming these camera conditions, the subject matter will appear in the same relative position with respect to the screen as it did with respect to the datum plane.

Some of the rules that should be adhered to are as follows:

1. For normal results the axis of the two viewpoints should be converged so as to intersect at a distance from the camera equal to the average intended viewing distance.

2. All subject matter that will appear on the screen should be kept, if possible, in sharp focus. Plain backdrops need not be in focus, but should be used if possible, to hide out-of-focus subject matter.

3. All objects photographed on the camera side of the datum plane should be contained within the common portion of the two cones XLY and XRY; hence they will not appear to touch the boundaries of the screen when viewed. Thus, objects appearing in front of the screen should not have any visible means of support, except possibly from a position behind the screen. Adherence to this rule is important, otherwise the brain will have difficulty in dealing with impulses that, on the one hand, signify that an object is actually between the observer and the screen, and on the other hand, signify that this same object is being partly obliterated by the boundaries of the screen.

4. The subject matter should be rotated or the camera moved around it whenever possible, so as to incorporate the "movement" factor of depth perception.

5. In respect to close-ups, if the subject cannot be contained in the space XYZ, the axes of the camera lenses should be converged on a point just in front of the subject. This will cause the subject to appear just beyond the screen plane when viewed, and increased in size. The increase in apparent size of the subject in this case will be directly proportional to the convergence distance divided by the viewing distance.

Since most close-ups require converging on a point closer than the intended viewing distance, they will also require an artificial far plane or backdrop. This is necessary, first, to prevent the far image displacement distance (D) from increasing beyond 2½ in. on the screen when projected, and, second, to eliminate unwanted out-of-focus subject matter.

The formula for determining the maximum subject distance (M) when the convergence distance (S) is less than the intended viewing distance, or

when the interocular is greater than $2\frac{1}{2}$ in. is derived as follows:

Referring to the diagram (Fig. 6), it may be seen that:

$$\frac{M + S}{D} = \frac{M}{D} \text{ or } M = \frac{DS}{B - D}$$

It has been previously shown that D could not be greater than $^1/_{28}$ of the distance XY. Thus, for example, if

S = 60 in., XY = 14 in., and B = $2\frac{1}{2}$ in. then

$$M = \frac{\frac{14}{28}(60)}{2\frac{1}{2} - \frac{14}{28}} = 15 \text{ in.}$$

THE ALTERNATE-FRAME STEREO CAMERA

Four different cameras have been adapted by the author for alternate-frame stereo motion picture photography. With this equipment a wide variety of applications has been possible. It should be noted that the mission of the Stereo Unit, AMC Photographic Service Center, Wright-Patterson Air Force Base, is to accomplish any type of stereo photography which it might be called upon to perform.

16-Mm cameras which have been adapted for alternate-frame stereo photography are; the Bell & Howell Filmo (Fig. 7), the Eastman High-Speed (Fig. 8), an Eastman High-Speed with Graham transmission (Fig. 9), and a Cine Special. Each of the cameras listed now accomplishes the requirement of exposing the right and left stereoscopic images on alternate full frames of the film.

Cameras equipped with barrel-type shutters lend themselves conveniently to alternate-frame stereo adaptation. In such cases the barrel-type polarizer principle can be incorporated as an integral part of the shutter. A split Polaroid filter on the lens of the camera, then, provides for alternate selection of the right and left views on each 180° rotation of the shutter. The axis of polarization of either half of the split filter on the lens is 45° to the vertical and opposed by 90°. Since the axis of polarization of the filter in the shutter is also on a 45° diagonal, it acts, together with the split filter on the lens, to eclipse alternately either half of the latter during each half revolution (see Fig. 10). Thus when a beam splitter is centered in front of the lens the displaced right and left views therefrom, entering their respective halves of the lens, are recorded selectively on alternate frames of the film. This method of selection is particularly advantageous in high-speed work where, otherwise, a mechanical shutter selector would be impractical.

High-Speed Adaptation

Both of the Eastman high-speed cameras illustrated in Figs. 7 and 8 are equipped with a Polaroid filter mounted in the barrel shutter compensator. Figure 10 shows this type of compensator positioned over a split Polaroid filter. Note that the left half of the filter as seen through the barrel of the compensator has been eclipsed. If the compensator had been rotated 180° from the position shown, the right half of the filter would have been eclipsed. The left side would have remained clear. The compensator shown was specially constructed by Eastman Kodak Co. It contains a sheet of Polaroid mounted between two optical glass plates. The refracting action of this optical assembly corresponds to the specifications of the standard Eastman high-speed compensator. Since there are no additional moving parts involved in the high-speed stereo adaptation, the camera can be operated at its maximum speed. There is one disadvantage in

Fig. 7. Motorized Bell & Howell Filmo Camera with stereo alternate-frame selector.

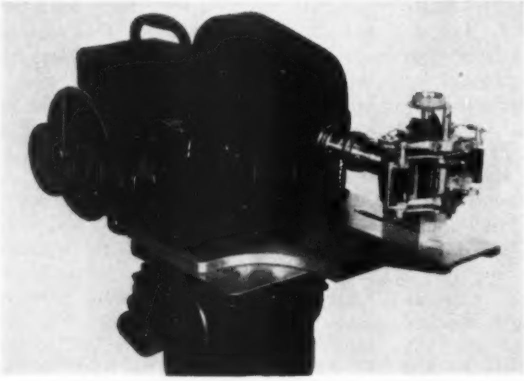

Fig. 8. Eastman high-speed camera equipped for alternate-frame stereo photography.

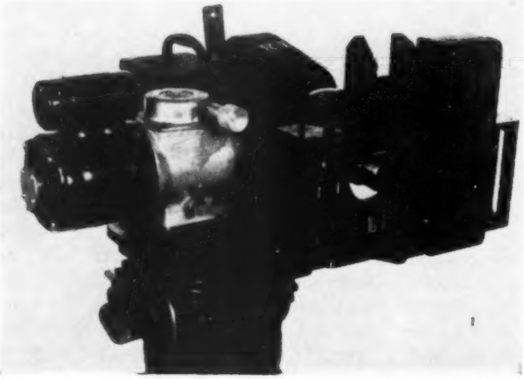

Fig. 9. Eastman high-speed camera equipped with Graham transmission and beam splitter for stereo photography at constant speeds from 0 to 176 frames/sec.

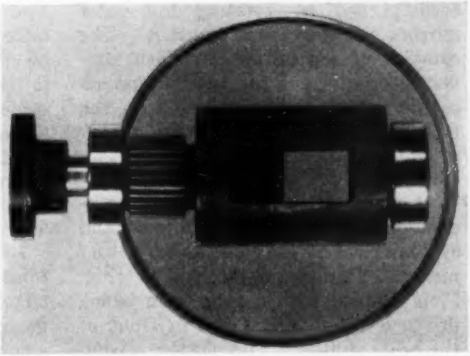

Fig. 10. Polaroid compensator used in the Eastman high-speed camera shown positioned over a split polaroid filter which is used on the lens of the camera.

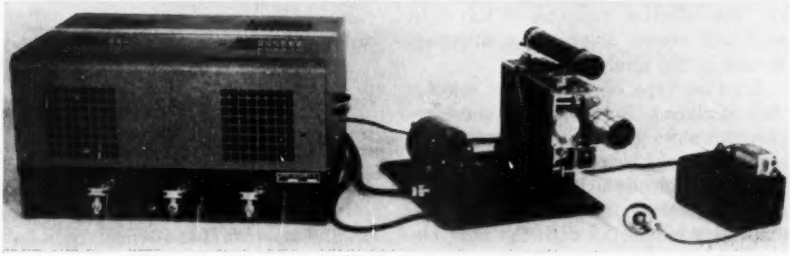

Fig. 11. Time-lapse equipment including step relay and solenoid-actuated lens attachment which alternately exposes right and left apertures of a stereo diaphragm over the lens.

this system, however, in that two stops of light are lost through the Polaroid filters.

Because of the simplicity of the optical selection of right and left images provided by the barrel shutter, one of the Eastman high-speed cameras shown (Fig. 9) was modified to provide constant frame speeds over a range from 1 to 176 frames/sec. As can be seen, this was accomplished by powering the camera with a Graham transmission. Some of the scenes in the film (shown at the Convention) were shot with this camera at the normal speed of 24 frames/sec.

The beam splitters shown positioned in front of the lenses of the cameras in Figs. 8 and 9 are interchangeable, i.e., they can be used with either camera. The beam splitter shown in Fig. 8 in addition is used in the attachment shown on the Bell & Howell Filmo (Fig. 7). This provides a choice of either a 2½-in. interocular or a 6-in. interocular. The latter is used with the 4- and 6-in. lenses to maintain normal depth proportions. The 6-in. beam splitter is equipped with a parallax-free view-finder which incorporates a half-silvered beam displacer. This feature provides a method of accurately registering the right and left beam-splitter images with respect to the central view-finder image. The actual registration of the separate images is

accomplished by rotating the outer mirrors of the beam splitter. The rotation of the mirrors in effect converges or diverges the two viewpoints of the system in accordance with the rules previously outlined.

Mechanically Operated Selectors

At normal and slower speeds mechanical shutters can be operated and synchronized by the camera or by other means. The Filmo mechanism (Fig. 7) is coupled with a gear train which drives a 180° shutter out in front of the beam splitter. This shutter accomplishes the same task as the optical selectors in the high-speed cameras, i.e., the selective exposing of the right and left stereo images on alternate frames of the film.

Another type of mechanical selector was designed for use in time-lapse photography (see Fig. 11). Here advantage was taken of the pulse timer which periodically actuates both a light circuit and the camera. A solenoid and step relay connected with the light circuit actuates a small oscillating shutter at every other impulse. The shutter is mounted on the lens and positioned over one of two apertures in a diaphragm also over the lens. Thus on every other impulse the shutter oscillates to a position over the normally open aperture causing the exposure to be made through the normally closed aperture. The apertures in this particular case have a displacement of ⅝ in., but can be expanded by placing a beam splitter in front of the shutter assembly. The stereoscopic time-lapse scene in the film shown was made with this equipment using a 50-mm lens and a ⅝ in. interocular.

Conclusion

In view of the versatility of applications possible with the alternate-frame technique, and in view of the full-frame quality possible therewith, and assuming that the few remaining problems can be ironed out, this system may prove to be a practical as well as a valuable medium of synthesizing natural vision.

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Continuous Processing Machine for Wide Film

By Herbert E. Hewston and Carlos H. Elmer

A new continuous processing machine for wide film carries the principles of motion picture film processing into the field of processing black-and-white film ranging in width from 70 mm to 12 in. Details of design and operation are outlined.

At the Naval Ordnance Test Station many kinds of quantitative data from test firings of rockets and guided missiles are recorded on special cameras which use film wider than 35 mm. These cameras include the Bowen Ribbon-Frame camera, described by Green and Obst,[1] which uses 5½-in. film; K-17 aircraft cameras modified for ground-to-air recording which use 9½-in. film; and various types of oscillographs which use film up to 12 in. in width. Until recently, these film records have been processed in small-capacity aerial roll-film processing units of the Smith-Fairchild or Morse types. After processing, the films were dried on a revolving drum.

Since a single day's test firing may result in exposure of several thousand feet of wide film, the inability of small tank processing to handle this material was evident. This was especially true because of the rigorous time limits imposed on the processing laboratory so that the film records might be examined in time to change subsequent firing conditions.[2] There was also a need for a processing method which would provide greater uniformity in the finished film product than was possible with the small tank method. To meet the requirements of this Station, design of a continuous wide film processing machine was initiated in 1948.

In June, 1949, the design and performance specifications had been formulated. The contract for construction was awarded to Imagineering Associates, Inc., of Pasadena, Calif., where the machine was constructed under the general supervision of Irving W. Akers. The machine was delivered to this Station in December, 1949. After installation and some subsequent modification, it was placed in production during September, 1950.

The components are shown schematically in Fig. 1. The machine is divided into three main parts: the darkroom wet-end section, the wash section and the dry box. Figure 2 shows the entire machine.

Presented on April 30, 1951, at the Society's Convention in New York by Herbert E. Hewston and Carlos H. Elmer, Photographic Laboratory Branch, U.S. Naval Ordnance Test Station, Inyokern, China Lake, Calif.

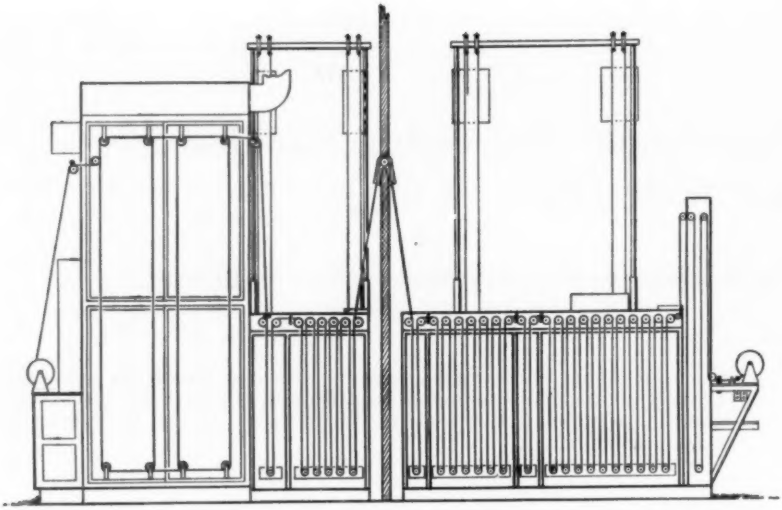

Fig. 1. Schematic diagram of continuous processing machine for wide film.

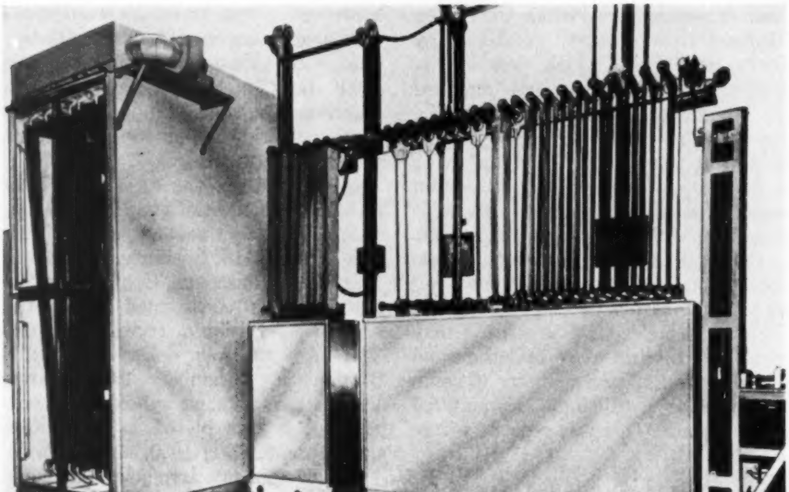

Fig. 2. Continuous processing machine for wide film.

Each of the three sections is driven by a separate synchronous motor directly coupled to a Graham transmission. The three drive units are selsyn-coupled to speed controls mounted on the take-up end of the dry box. Machine speed is governed by a metering roller immediately preceding the developer tank. The rest of the top rollers are overdriven through friction clutches from a flat endless belt which is driven from the metering roller. Top rollers are supported by fixed stainless steel tubing which is connected by flanges to the main roller rack support beam. These top rollers ride on plain bearings made of nylon. The roller rack assemblies are counterbalanced and attached to hoists which raise the rack assemblies a maximum of 6 ft to bring the bottom rollers above the tops of the tanks for maintenance purposes. The bottom idling rollers in the wet end are mounted on bearings made of Teflon, a Du Pont plastic with low friction properties. Nylon bearings were first used at these points, but difficulty was encountered from friction between the roller shafts and the bearings. The wet film would tend to slide across the rollers without turning them. The substitution of Teflon bearings eliminated this difficulty. The dry box drive is also applied on the top rollers by spring belts from friction-driven shafts.

The loading ledge, shown in Fig. 3, is equipped with an automatic run-out brake and audible alarm. As the film end leaves the feed-in reel the brake is applied, the loading elevator starts to rise, and an audible alarm is sounded. If the elevator rises completely to the top, the machine drive will stop.

The film loop length in the developer tank may be remotely adjusted from the control panel from a maximum extension of 5 ft to a minimum of 2½ ft (linear film length of 10 ft and 5 ft respectively), or any intermediate point between these limits. This adjustment in loop length, which can be made while the machine is in operation, permits a wide variation in developing time at a given machine operating speed. Film loops may also be dropped to further shorten the developing time. The adjustable loop feature is illustrated in Fig. 4, while Fig. 5 shows the graph from which developing times are determined. Temperature control of the developing solution is obtained by forced circulation of the solution through a heat exchanger made up of alternating solution and tempered water baffles. The solution flow through the heat exchanger is indicated by the arrows in Fig. 6. These heat exchanger baffles can be readily dismantled for cleaning. After temperature conditioning in the heat exchanger, the solution re-enters the developing tank through jet headers,

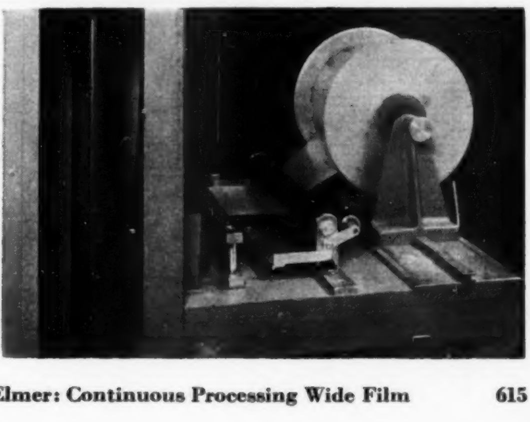

Fig. 3. Loading ledge of machine, with automatic run-out break and audible alarm.

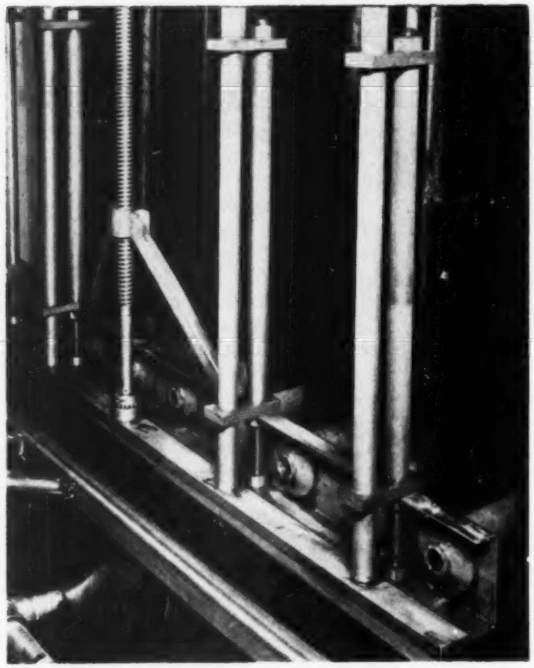

Fig. 4. Adjustable loop mechanism.

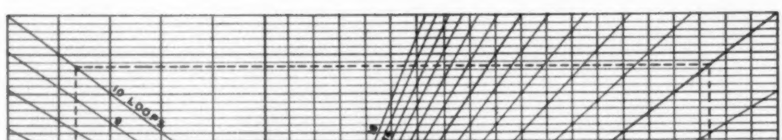

Fig. 5. Graph relating loop length, number of loops, film speed and developing time

thus producing agitation. The developer tank has a capacity of 225 gal, and is followed by a 39-gal stop bath tank and a 137-gal hypo tank. The fixing solution is temperature controlled by forced circulation through a section of the same heat exchanger. The hypo tank is followed by a 39-gal rinse tank, after which the film goes from the darkroom through a light-tight film pass to the wash tank. Figure 7 shows the dark-end tank section.

The 115-gal wash tank can be filled to 30, 60 or 90% of capacity, or can be operated empty with complete spray washing. Jet action is provided by the spray headers either above or under water. The wash water is obtained from the special Photographic Laboratory supply of temperature-controlled water. Since the line water frequently

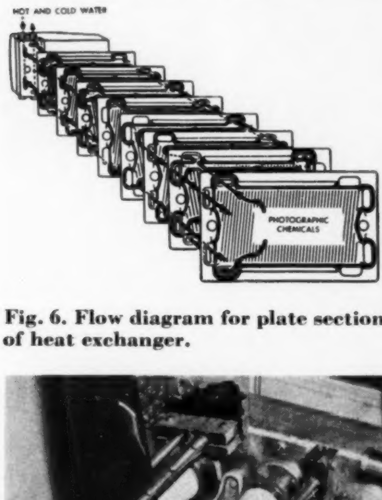

Fig. 6. Flow diagram for plate section of heat exchanger.

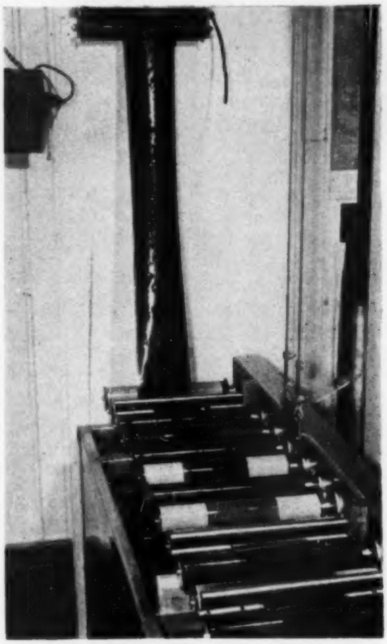

Fig. 7. Dark end roller rack in lowered position, ready for processing.

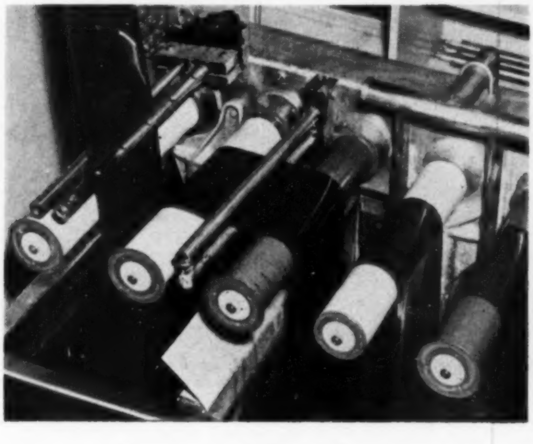

Fig. 8. Typical squeegee installation.

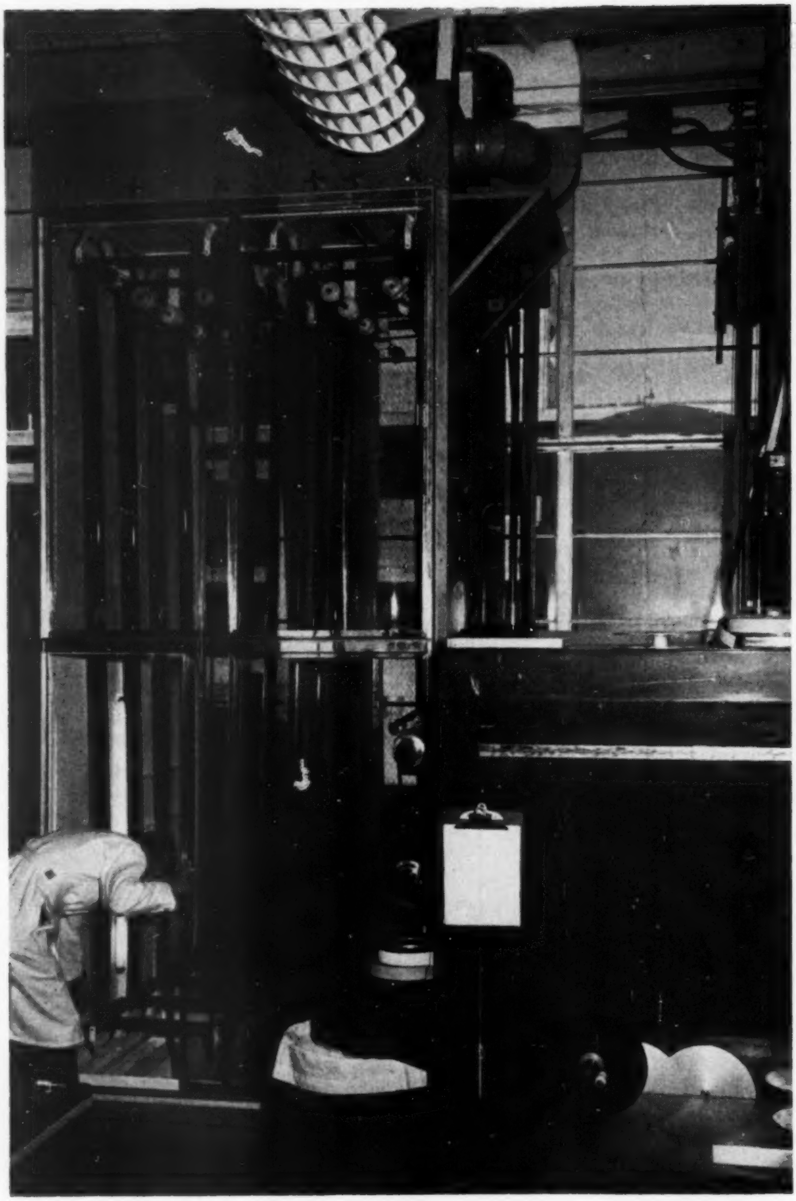

Fig. 9. Dry box.

reaches 85° F during the summer in this desert locality, a chilled water supply is required for proper record-film processing. The wash tank is followed by another 39-gal rinse tank containing an aerosol solution.

A rubber knife edge squeegee is located between each two liquid tanks

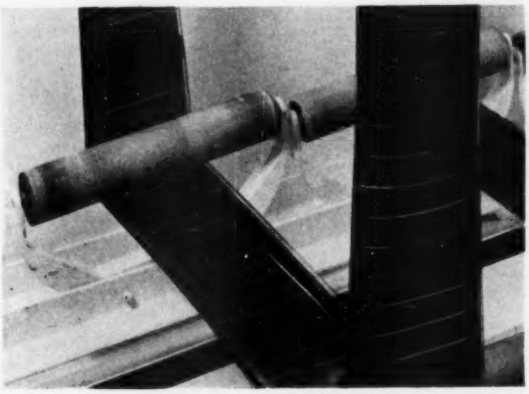

Fig. 10. Angle of film progression in drying cabinet.

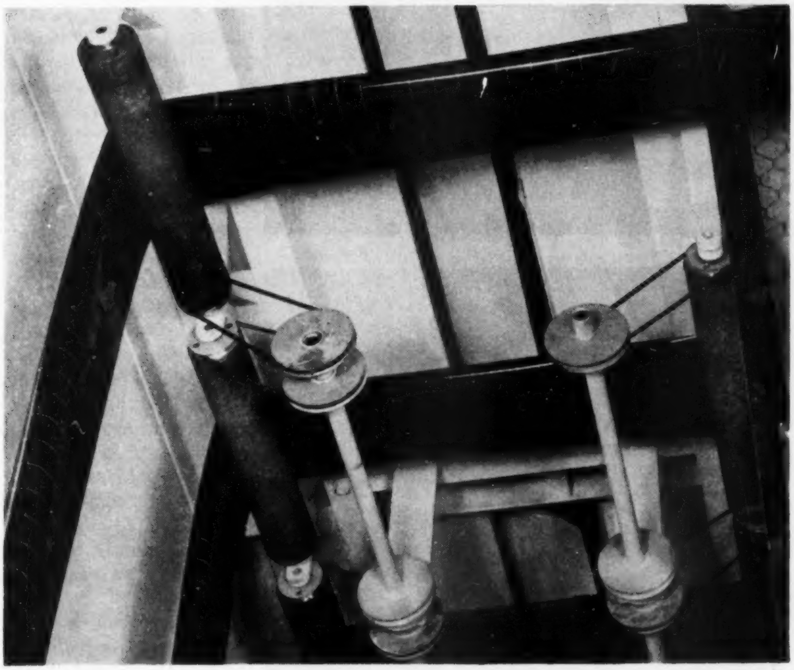

Fig. 11. Dry-box top film rollers.

and between the final rinse tank and the dry box. A typical squeegee installation can be seen in Fig. 8.

The dry box is shown in Fig. 9. While the film's emulsion touches the submerged bottom rollers in the liquid tanks, roller contact is made only with the film base in the dry box. This is

Fig. 12. Machine's control panel.

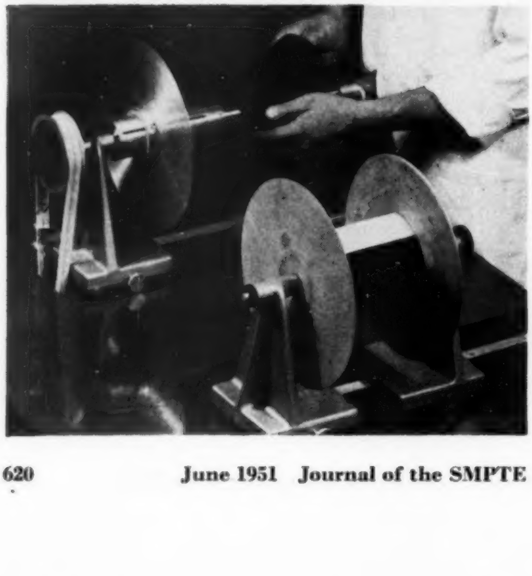

Fig. 13. Power-driven rewind assembly.

accomplished through the mounting of the dry-box rollers on individual shafts at such angles as to permit 14 in. of side movement per film wrap. Two wide passes of four wraps each are made through the dry box, which is 6 ft square and 14 ft in height. This configuration, which is not ideal from the standpoint of operating efficiency, was made necessary by space limitations in the laboratory. The angle of film progression in the drying cabinet is shown in Fig. 10, while Fig. 11 shows the manner in which dry-box top film rollers are driven through spring belts from drive shafts which are parallel to the roller centers. The drive shafts are chain driven through friction clutches.

Details of the control panel are shown in Fig. 12. The control panel contains, at the top, Powers temperature-control instruments for the developer and hypo solutions, and, in the center, the machine drive start and stop button, and the developing time graph. A tachometer, speed-change control wheel and lock button, a dry-box blower switch, and dry-box heater selector switches are located at the left. On the right are the developer-rack loop-length indicator, loop-length control buttons which raise or lower the bottom-roller assembly, and the dry-box light switch.

The film take-up assembly, like the feeding assembly, is adjustable in width from 35 mm, the size of the leader, to 12 in. The 1,000-ft rolls of processed film are broken down into individual rolls for delivery, using a special power-driven rewind assembly, which may be seen in Fig. 13.

The machine's operating speed ranges from a minimum of 3 ft/min to a top speed of 15 ft/min. A speed of 10 ft/min is generally used. Developing time can be varied from 1 min to 20 min.

Since the machine has been placed in production, it has processed well over 100,000 ft of wide film, and daily runs of more than 3,000 ft are not uncommon. As a comparison, 3,000 ft of 9½-in. film is equal in area to 21,000 ft of 35-mm film.

A definite improvement in consistency of processing quality has been achieved, and the machine has proven to be of great assistance in the rapid production of wide-film records depicting the progress of our ordnance development and testing programs.

It had been planned that the new machine would also be used as a research tool in the investigation of such matters as the effects of various processing conditions upon dimensional stability of wide-film bases, etc. To date, the volume of processing has not permitted this program to be undertaken, but it is expected that some findings in this field may be obtained within the next year.

During the testing and operating of the new wide-film machine, many problems have been encountered which might be unique to the field of machine processing of film greater in width than 35 mm. While several of these problems have been satisfactorily overcome, others remain to be solved. Besides providing this Station with a means of increasing its output of wide-film records, it was assumed that the construction and use of such a machine would also provide a fund of information on this subject which might be of value to others planning installation of similar facilities.

(All photographs are official photographs of the U.S. Navy.)

References

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2. C. H. Elmer, "Photography in the rocket-test program," *Jour. SMPTE*, vol. 54, pp. 140–148, Feb. 1950.

Discussion

H. W. SACHS: With regard to the contour rollers which are cylindrical in the wet section, does it facilitate the operation if the rollers in the dry box have a very slight crown to them?

MR. HEWSTON: That was one of the problems we overcame simply by reinforcing everything. We found if everything was nice and true, so was the film.

ROY WOLFORD: Have you attempted to use the same principle in processing long lengths of paper?

MR. HEWSTON: We are processing paper on it, as well as film.

MR. WOLFORD: At the same maximum running speed?

MR. HEWSTON: Yes.

NORMAN EXLEY: What is the purpose of the provision for operating with the wash tanks either empty or partly full?

MR. HEWSTON: We have found that more turbulence is produced by using a spray in a tank that is empty. In other words, the film is not immersed but you get some soaking.

MR. EXLEY: What is the usual method of operation?

MR. HEWSTON: We have operated it several ways. We find maximum efficiency at about 30% of full. You get a little bit of soaking and a lot of jet action on the surface.

JOHN CRABTREE: What material is used for the gaskets? Also, how long does it take to load the machine?

MR. HEWSTON: The gaskets (heat exchanger) are Neoprene and they are used for the same purpose as any others. It is the only means of retaining the solution within the confines of the chamber. The plates themselves are corrugated to give a certain definite distance between each plate.

The other question on loading: It is 600 feet through. At 10 feet per minute the time through would be one hour. The time to load on a new roll of film, that is to splice on a new roll, is about 20 seconds.

ANON.: Explain the use of the gaskets in the heat exchanger.

MR. HEWSTON: To include or exclude ports in the baffles and to establish the desired flow of two separate solutions, namely, the tempered solution and the solution being tempered.

ANON.: Were tape splices used?

MR. HEWSTON: Yes.

MR. EXLEY: Is developer activity maintained by batchwise or continuous replenishment?

MR. HEWSTON: Continuous replenisher controlled through chemical analysis.

Slide Rule for Analyzing High-Speed Motion Picture Data

By Karl W. Maier

In mechanics research, evaluation of high-speed motion picture records involves several basic calculations which have to be repeated very often. The Springfield Armory has developed a special slide rule which will mechanically perform these computations, as well as some precalculations before taking the picture. It is believed that the proposed slide rule permits more rapid evaluations with fewer errors and with less highly trained personnel.

This analysis covers standard 16- and 8-mm motion picture films, with the standard timing marks, 1000 or 60 timing units per second, as used in mechanics research (Fig. 1).

A motion picture engineer often has to make basic calculations in evaluating a given high-speed motion picture record. Of special interest are the operating time of a certain machine part and the cyclic rate of the mechanism to be investigated. Direct counting of the corresponding number of timing units is too tedious when the operating time, as is usual, extends over a great number of frames. Therefore, it is better instead to count the corresponding number of frames and the operating time is calculated from this. Although the formulae involved are comparatively simple, considerable time is consumed in reading values from the film as well as in the elementary calculations, and thus, series investigations, desirable for one reason or another, would appear to be impractical. Furthermore, the motion picture engineer must determine optimum operating conditions for the camera before taking a picture. In order to reduce time and errors, a mechanical method of computation would be of advantage and solve both problems.

R. F. Ledoux, head of the Springfield Armory Photographic Laboratory, expressed the desire for an instrument that would fulfill such requirements, and a beginning was made. First, charts were used and from them there was finally evolved a special slide rule, which should satisfy a long-felt need for more rapid evaluations. Although this slide rule was originally intended for weapon research and development, it is believed that it can be used equally well in the entire field of mechanics research. The first model has been fabricated and tested by the Photographic Laboratory of Springfield Armory, and has proved to be a great time saver. A patent application has been filed.

This proposed evaluation method is

Presented on May 3, 1951, at the Society's Convention at New York, N.Y., by Karl W. Maier, Springfield Armory, Springfield 1, Mass.

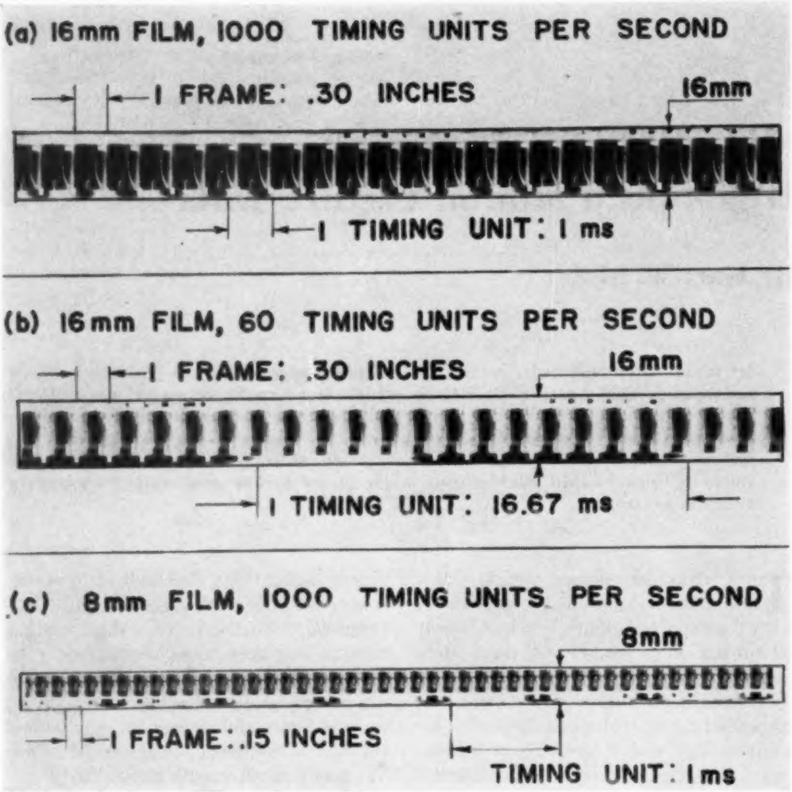

Fig. 1. Standard films with timing marks.

based on a simplified reading of values from the film. For evaluation purposes, the length of the film is divided into parts, over which the original film velocity (during film run in the camera) can be considered constant, depending on the acceleration of the film and accuracy desired. Within such a part of film, any time interval and the corresponding number of frames are in constant proportion. This can be designated as the "frame time," i.e., time value of one frame.

The number of frames representing a certain operating time is counted either visually (when small) or by means of a mechanical frame counter, the latter being either on the projector or separate. The height of one frame, 0.30 in. for 16-mm film and 0.15 in. for 8-mm film, is used as the unit of length for the film, thus eliminating any length measurements in the direction of film motion by means of a scale.

With regard to time, only small time intervals consisting of a few timing units are counted visually. Greater time intervals are calculated by means of the slide rule, using the frame time and the corresponding number of frames.

Nomenclature

Note: Whenever film velocities or time intervals on the film are given, the film run in the camera when the picture was taken is meant; the velocity of the film when being projected is not of interest here.

Symbol	*Description of Symbol*	*Unit*
N	Any number of frames or pictures in a given part of the film	frame
N′	Number of shots in a burst	shot
t	Any time interval of film	ms
t_1	Frame time, i.e., time value of one frame during the film run in the camera	ms/frame
T	Total running time of film	sec
T′	Duration of a burst fired or time to be recorded	sec
i_{1000}	Any (whole) number of timing units when using 1000 timing units per second (frequency 1000)	1 ms
i_{60}	Any (whole) number of timing units when using 60 timing units per second (frequency 60)	16.67 ms
v	Velocity of film in the camera	ft/sec
V	Velocity of film in the camera	frames/sec
v_{max} (V_{max})	Maximum film velocity near end of film run in the camera	ft/sec (frames/sec)
$\bar{v}$ ($\bar{V}$)	Average film velocity over total running time	ft/sec (frames/sec)
v_{min} (V_{min})	Minimum film velocity permissible for sharp pictures	ft/sec (frames/sec)
n	Cyclic rate of a mechanism	rpm
v^*	Maximum velocity of moving machine part	ft/sec
$\bar{v}^*$	Average velocity of moving machine part over given travel distance	ft/sec
s	Travel distance of machine part	in.
w	Width of field in the distance of moving parts covered by the effective width of the film (see Fig. 3)	in. (ft)

To establish the scales of this slide rule, some preparatory work, such as defining characteristic values and analyzing mathematical relationships used in the basic computations, had to be done first.

Basic Tasks for Evaluating Film Records and Formulae Used

With a given motion picture record, the relationship between a certain time interval and the corresponding number of frames is of general interest and will aid in standardizing evaluations. This time-length relationship can be indicated either by the "frame time" in ms/frame, or by the film velocity measured in ft/sec or frames/sec. Both values vary over the length of the film. This brings up the following questions:

What is the *frame time*, t_1, at any point of the record? N frames of the film may correspond to the time t, or i_{1000} timing units or i_{60} timing units (i_{60} and i_{1000} are whole numbers); the frame time then becomes:

$$t_1 = \frac{t}{N} = \frac{i_{1000}}{N} = \frac{50 \cdot i_{60}}{3N}, \text{ in ms/frame.} \quad (1)$$

For example: When 5 timing units of the 1000-cycles timing correspond to 8 frames, the frame time then becomes:

$$t_1 = 0.625 \text{ ms/frame.}$$

What was the *film velocity* in the camera, v, in ft/sec (or V, in frames/sec), at any point of the given record? N frames may correspond to the time t, or i_{1000} timing units or i_{60} timing units, then the film velocity is:

$$V = \frac{1000}{t_1} = \frac{1000 \cdot N}{t} = \frac{1000 \cdot N}{i_{1000}} = \frac{60 \cdot N}{i_{60}}, \text{ in frames/sec.} \quad (2)$$

For example: With 8 frames in i_{1000} = 5 timing units, a film velocity of 1600 frames/sec results. The corresponding film velocity v, measured in ft/sec, as well as the relationship between v and V, depends on the type of film.

16-Mm Film:
$$v = \frac{25}{t_1} = \frac{25 \cdot N}{t} = \frac{25 \cdot N}{i_{1000}} = \frac{1.5 \cdot N}{i_{60}}, \text{ in ft/sec,} \quad (3)$$

with the relationship

$$V = 40 \cdot v, \text{ in frames/sec.} \quad (4)$$

With 8 frames in 5 ms, a film velocity of 40 ft/sec results.

8-Mm Film:
$$v = \frac{12.5}{t_1} = \frac{12.5 \cdot N}{t} = \frac{12.5 \cdot N}{i_{1000}} = \frac{0.75 \cdot N}{i_{60}}, \text{ in ft/sec,} \quad (3')$$

with the relationship

$$V = 80 \cdot v, \text{ in frames/sec.} \quad (4')$$

With 8 frames in 5 ms, a film velocity of 20 ft/sec results.

Frame time and film velocity are related values. They always satisfy relationships (2), (3) and (3′). Both values are also used advantageously for special evaluation tasks, such as determining operating time of a machine part, cyclic rate of a mechanism, etc.

What is the *operating time of a machine part,* when the former comprises N frames on the film?

The beginning and ending of the operation have been marked and N frames have been counted for this time interval. First, the frame time, t_1, has to be determined according to (1), by evaluating a short time interval, consisting of a few timing units in the middle of operating time. Then the operating time, t, is:

$$t = N \cdot t_1, \text{ in ms.} \quad (5)$$

For example: With the above frame time of 0.625 ms/frame, an operation comprising 80 frames lasts 50 ms. For a long operating time, the frame time, t_1, may be taken at the beginning and at the end of operation and the average value thereof may be used for calculations.

What is the *cyclic rate* of a gun (or other mechanism) when N frames are counted for the cycle time, t? Using frame time t_1, the cycle time is given by Eq. (5) and the cyclic rate follows:

$$n = \frac{60{,}000}{t} = \frac{60{,}000}{N \cdot t_1}, \text{ in rpm.} \quad (6)$$

For example: With the above frame time of 0.625 ms/frame and 80 frames per cycle, the result is a cyclic rate of 1200 rpm.

What was the approximate *total running time of the film,* T, in seconds?

To answer this question, the average film velocity over the total running time, $\bar{v}$ or $\bar{V}$, should be known. Figure 2 illustrates the acceleration characteristic of film run, that is, the increase of film velocity during film run in the camera. The average film velocity, $\bar{V}$, is somewhat lower than the maximum film velocity near the end of the film run V_{max}. How much lower it is depends on the type of camera and, eventually, on the voltage used. For one type of high-speed motion picture camera the proportion

$$\frac{\bar{V}}{V_{max}} = \frac{\bar{v}}{v_{max}}$$

was found to be approximately 0.8. To have more accurate data available, the acceleration characteristics should be determined for all types of cameras and voltages used. Based on a film length of 100 ft, the total running time then is:

$$T = \frac{100}{\bar{v}} \text{ sec.} \quad (7)$$

When introducing the film velocity in frames/sec:

16-mm film: $$T = \frac{4000}{\bar{V}} \quad (8)$$

8-mm film: $$T = \frac{8000}{\bar{V}} \quad (8')$$

For example: With a maximum film velocity, $v_{max} = 70$ ft/sec ($V_{max} = 2800$ frames/sec for a 16-mm film), the average film velocity is approximately 56 ft/sec or 2240 frames/sec, which means a total running time of 1.78 sec.

What is the *average velocity of a machine part*, $\bar{v}^*$, when its travel over a known distance of s inches corresponds to N frames on the film?

First, the corresponding time t, in ms, has to be determined according to equations (1) and (5). Then the average velocity is:

$$\bar{v}^* = 1000 \cdot \frac{s}{t} \text{ in./sec.} \quad (9)$$

or $$\bar{v}^* = 83.33 \cdot \frac{s}{t} \text{ ft/sec.} \quad (9')$$

For example: With s = 4.8 in., and t = 25 ms, the average velocity is $\bar{v}^* =$ 16 ft/sec.

Basic Tasks for Precalculation and Formulae Used

This second group of tasks comprises calculations which must be made prior

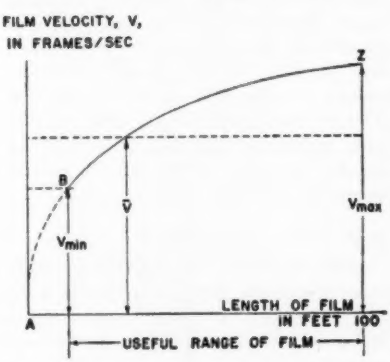

Fig. 2. Acceleration characteristic of film run.

to taking a picture in order to determine optimum operating conditions for the camera.

1. Time to Be Recorded

What is the time of a burst of N′ shots, T′, when fired with a cyclic rate of n rpm?

$$T' = \frac{60 \cdot N'}{n} \text{ sec.} \quad (10)$$

For example: A burst of 25 shots, fired at a cyclic rate of 1200 rpm, lasts 1.25 sec. Since the initial run of the camera does not give sharp pictures due to the low film velocity in the beginning (see Fig. 2), the burst and its recording is started with a certain delay after the beginning of film run by means of an electronic timing device. Assuming that a delay of 0.50 sec is necessary, the total running time of the film, T, has to be at least 1.75 sec in order to cover the whole burst. Therefore, the time to be recorded, T′, prescribes a lower limit for the total running time, T, or, in other words, an upper limit for the maximum film velocity, V_{max}. To select the right maximum film velocity and corresponding voltage, the acceleration characteristic of the camera and some additional data must be given.

2. Minimum Film Velocity

What is the minimum film velocity permissible for sharp pictures, v_{min} or V_{min}?

The image of a moving gun part on the film also moves during exposure time of the corresponding frame and brings about a blurred picture (see Fig. 3); therefore, the image travel per frame must be less than a certain limit, when sharp pictures are desired. The factors determining the image travel are:

Maximum velocity of machine part, v^*: The faster the machine part is moving, the greater will be the image travel during exposure time. Here, only the projection of the velocity onto a plane

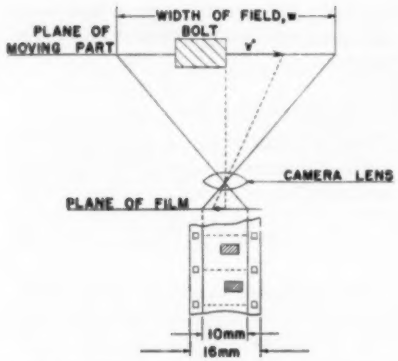

Fig. 3. Relationship between object and image.

through the moving part, parallel to the camera lens, has to be considered.

Reduction of image in camera: This defines the proportions of image to object dimensions (see Fig. 3). It can be expressed in terms of the width of field, w, which is covered by the effective width of the film, the latter being approximately 0.4 in. for the 16-mm film and 0.2 in. for the 8-mm film. The reduction itself then becomes 0.4/w and 0.2/w, respectively.

Exposure time of one frame and film velocity: The image travel per frame changes in proportion to the exposure time, i.e., in the inverse ratio to the film velocity (assuming a constant ratio of exposure time to frame time).

With one type of high-speed motion picture camera the permissible image travel during exposure time, which still guarantees sharp pictures, is 0.002 in. This means approximately 0.010-in. image travel per frame, since the exposure time is about one-fifth of the frame time. The film velocity, therefore, must be greater than a certain lower limit, V_{min}, in order to obtain sharp pictures. This means that the beginning of the film, moving with velocities less than V_{min} during exposure, cannot produce records meeting all requirements.

Based on an image travel of 0.010 in. per frame, the following formulae are obtained for the minimum film velocity (compare with chart for selecting speed given by Eastman Kodak Co.):

16-mm film:

$$v_{min} = 12 \cdot \frac{v^*}{w} \text{ ft/sec} \qquad (11)$$

$$V_{min} = 480 \cdot \frac{v^*}{w} \text{ frames/sec} \qquad (12)$$

8-mm film:

$$v_{min} = 3 \cdot \frac{v^*}{w} \text{ ft/sec} \qquad (11')$$

$$V_{min} = 240 \cdot \frac{v^*}{w} \text{ frames/sec} \qquad (12')$$

For example: When a machine part moving with a maximum velocity $v^* =$ 40 ft/sec has to be photographed on 16-mm film within a field 10 in. wide, only film velocities greater than 48 ft/sec or 1920 frames/sec will guarantee sharp pictures. For 8-mm film, the film velocity must be greater than 12 ft/sec or 960 frames/sec, with the same velocity of machine part and width of field assumed.

3. Conclusion

The correct film velocity to be chosen for recording lies within a range where the lower limit is determined by claiming sharp pictures, while the upper limit is prescribed by the time to be recorded and possibly by the illumination required to obtain a suitable exposure. The acceleration characteristic of film run, illustrated in Fig. 2, should be known for each camera under various operating conditions.

Description of Slide Rule

Since the above formulae involve only multiplications and divisions, a slide rule based on logarithmic scales seems to be the best approach to a mechanical computer.

The slide rule developed consists of three parts, the *body*, the *slide* and the

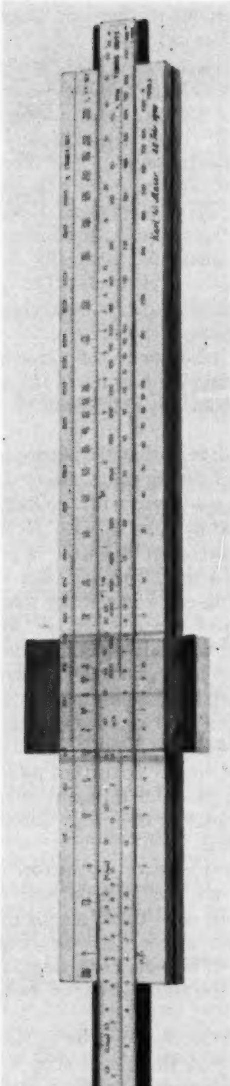

Fig. 4. Model of linear slide rule for analysis of high-speed motion picture films.

indicator, the latter two moving in longitudinal grooves of the slide rule body (see Fig. 4).

The slide rule *body* has three log scales, one below and two above the slide groove.

N-scale: This scale is used for the number of frames or pictures contained in any interval of film with a range from 1 to 1000 frames (additional use for the number of shots in a burst, N′). Index "1" of the scale has an arrow (t_1) for reading of the frame time, t_1, in the t-scale of the slide.

v-scale: This scale is used for the film velocity, v, as well as for the velocity of a moving part, v^*, both measured in ft/sec. It has two readings, the lower one from 1 to 1000 ft/sec for 16-mm film only, the upper one with a range from 0.5 to 500 ft/sec for 8-mm film only. These are referred to as upper and lower v-scale.

V-scale: Here the film velocity, V, in frames/sec is shown for both 16-mm and 8-mm film. The range extends from 100 to 20,000 frames/sec.

The *slide* is purposely longer than the body in order to cover a wide range of time. It has five log scales.

t-scale: This scale has a double use, either for time, measured in ms, or for the number of timing units, i_{1000}, when using 1000 timing units/sec. The range extends from 0.1 to 1000 ms.

i_{60}-scale: This scale shows the number of timing units, i_{60}, when using timing frequency of 60/sec, with a range from 1 to 60, i.e., 16.67 ms to 1000 ms. At the 1.5 division of this scale, there is an arrow (v) for reading of the film velocity in the v-scale or V-scale.

n-scale: This scale shows the cyclic rate of an automatic gun or mechanism per minute, with a range from 100 to 10,000 rpm.

Upper w-scale: w indicates the width of field in inches, which is covered by the effective width of film as shown in Fig. 3. The range extends from 1 to 100 in. Arrows (8, v_{min}) and (16, v_{min}) point to

the film velocity, v_{min}, in the corresponding v-scale, or V_{min} in the V-scale.

Lower w-scale: This scale is for the width of field, w, measured in feet, with a range from 0.1 to 2.5 ft, to be used together with the upper w-scale for conversion of inches into feet and vice versa.

The transparent *indicator* has a hairline, perpendicular to the direction of the log scales, for alignment of the corresponding values in various scales.

Use of Slide Rule for Evaluation Tasks

1. Correct Slide Position With Reading of Frame Time and Film Velocity

To find the frame time, t_1, and the film velocity, v or V, in a given part of the film record, the procedure outlined below should be followed.

A part of the film strip, short enough so that the film velocity during film run in the camera can be assumed constant for evaluation purposes, should be considered. Then any time interval within this film part, t, will have a constant proportion to the corresponding number of frames, N, where this proportion is identical with the frame time, t_1, defined previously. For example, when i_{1000} = 5 timing units or 5 ms correspond to 8 frames, 10 ms will correspond to 16 frames, and the frame time is 0.625 ms. The following, therefore, applies to the slide rule: When *any* time, t, on the t-scale of the slide is aligned with the corresponding number of frames, N, on the N-scale of the slide rule body, *all* time values, t, will be aligned with the corresponding number of frames, N. Especially, index "1" on the N-scale, indicated by arrow (t_1), will be aligned with the frame time, t_1, on the t-scale. This slide position with the proper alignment of t-scale and N-scale may be called "correct slide position" for the given part of film with constant velocity. For another part of film with a different velocity, another positioning of the slide within the slide rule body will be the correct one. The procedure for determining the correct slide position, therefore, includes readings on the film as well as on the slide rule.

In the given part of *film*, select a small number of timing units, i_{1000} or i_{60}, and count the corresponding number of frames, N, by visual approximation or by means of the frame counter. For example, it will be found when i_{1000} = 5 timing units, N = 8 frames. Reading fractions of frames increases the accuracy of computation, especially for a smaller number of frames. The procedure for the *slide rule* is comprised of the following steps:

Move the indicator to the value 8 on the N-scale, i.e., the hairline of the indicator must coincide with value 8 (see Fig. 5).

Move the slide so that the corresponding number of timing units, i_{1000} = 5, of the i_{1000}-scale converges with the hairline on the indicator, that is, with N = 8. (When the corresponding time is given in terms of i_{60} timing units, then that value of the i_{60}-scale has to be aligned with N = 8 of the N-scale.) This is now the "correct slide position" for all evaluations of time and velocity within the given part of film assumed to have constant velocity. Corresponding numbers of frames of the N-scale, and times of the t-scale, are in alignment as illustrated in Fig. 5. For different evaluations in this part of film, only the indicator is moved.

Move the indicator to arrow (t_1) (index "1") on the N-scale and read the *frame time*, t_1 = 0.625 ms, in the t-scale. (When arrow (t_1) on N-scale falls outside of t-scale, read time, t, at N = 10 and the frame time will be t_1 = t/10.)

Move the indicator to arrow (v) inside i_{60}-scale and read the *film velocity* v and V in the corresponding v-scale and V-scale, respectively. For 16-mm film, v = 40 ft/sec and V = 1600 frames/sec. For 8-mm film, the result is v = 20 ft/sec and V = 1600 frames/sec. The frame time, t_1, and film velocity, v, which are related, can be considered

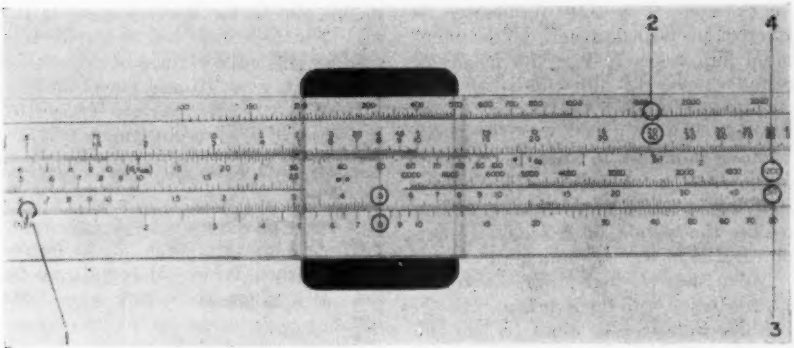

Fig. 5. Setting of slide rule to read.
(1) Frame time (2) Film velocity (3) Operating time (4) Cyclic rate

characteristic values for any such part of film with constant velocity.

2. Operating Time and Cyclic Rate

To find the operating time of a part, t, extending over N frames of the film and the cyclic rate, n, when one gun cycle comprises N frames:

Mark the beginning and end of operating time on the film.

Determine the correct slide position for this part of film according to Paragraph 1 above, by evaluating a time interval in the middle of operating time (or by taking the average of two evaluations, at the beginning and end of operation). The same slide position as in Paragraph 1 above, with frame time of 0.625 ms, may be assumed.

Count the number of frames corresponding to the given operation, N, in the film by visual approximation or by means of a frame counter. For example, N = 80 frames, may be found.

Move indicator to the numeral "80" in N-scale and read *time of operation*, t, in t-scale at the hairline. It will be found that t = 50 ms (compare with Fig. 5).

When this time of operation, t, is identical with the cycle time of the gun, read the corresponding cyclic rate, n = 1200 rpm, in the n-scale with the same indicator position, i.e., above t = 50 or N = 80 (see Fig. 5).

Note: The tasks described for determining frame time, film velocity, operating time and cyclic rate, represent the basic evaluation of a given film by means of the slide rule. All log scales, with exception of the two w-scales and at times the i_{sr}-scale, are involved. When several operating times must be evaluated in the same part of film with constant velocity, the slide remains in its correct position, and only the indicator needs to be moved. Therefore, the timesaving value of the slide rule is increased with the number of evaluations to be made within such a film part of constant velocity. In addition to the basic evaluation tasks, listed above, the slide rule can also be used like a standard slide rule, for other evaluations. In these cases, the final slide position no longer means the correct alignment of the N-scale and t-scale, but rather the adjustment of other scales with other meanings. To show this, two examples will be given in the following.

3. Total Running Time of Film (Approximate)

To find the *total running time* of the film, T, when the average film velocity,

for example, $\bar{V}$ = 2240 frames/sec, is given or has been derived from the maximum film velocity, V_{max}, by means of tested values, the slide rule is used for the solution of Eq. (7), (8) or (8′) as follows:

Move indicator to value $\bar{V}$ = 2240 frames/sec in V-scale. The corresponding average film velocity is then read in the v-scale, 56 ft/sec for 16-mm film and 28 ft/sec for 8-mm film.

Move slide so that "100" on the t-scale is in line with the indicator.

Move indicator to index "1" of the corresponding v-scale and read the total running time, T, in seconds at the hairline in the t-scale. T will be 1.78 sec for 16-mm film and 3.56 sec for 8-mm film.

4. Average Velocity of a Machine Part

To find the average velocity of a machine part, $\bar{v}^*$, when its travel over s inches corresponds to N frames on the film, *for example*, s = 4.8 in., N = 40 frames:

Determine time of travel, t in ms, according to Paragraph 2 above. In the numerical example (which follows Eq. (9′) above), t = 25 ms.

Move indicator to number "25" on v-scale for 16-mm film.

Move slide until number "4.8" in the upper w-scale coincides with the hairline.

Move indicator to index "1" on v-scale for 16-mm film and read the average velocity, $\bar{v}^*$, in the upper w-scale in in./ms and in the lower w-scale in ft/ms. For the numerical example, this reading falls outside the w-scale, but by reading at v = 10 and corresponding correction, an average velocity of 192 in./sec or 16 ft/sec is obtained.

Use of Slide Rule for Precalculation Tasks

1. Time to Be Recorded

To find the gun time, T, to be recorded, when N′ = 25 rounds, to be fired at a given cyclic rate n = 1200 rpm:

Move indicator to arrow (t_1) of N-scale.

Move slide, so that the given cyclic rate, n = 1200, lines up with the indicator.

Read the cycle time of the gun, t = 50 ms, in t-scale above arrow (t_1) of N-scale.

Move indicator to N = 25 in N-scale and read the time of a burst of 25 shots in the t-scale at the indicator. Because this reading falls outside the t-scale, the value 125 is read at N = 2.5 and multiplied by 10, so that a burst time of 1250 ms or 1.25 sec is the answer.

2. Minimum Film Velocity

To find the minimum film velocity permissible for sharp pictures, when the maximum velocity of the moving part, v*, and the width of field to be covered by a 16-mm film, are given, *for example*, when v* = 40 ft/sec, and w = 10 in.:

Move indicator to number "40" on lower v-scale for 16-mm film (see Fig. 6).

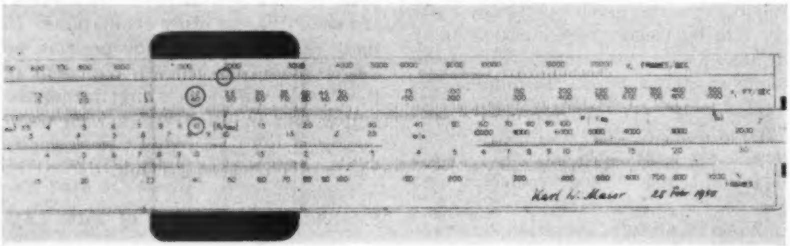

Fig. 6. Setting of slide rule to determine the minimum film velocity required to obtain sharp pictures.

Move slide so that number "10" in upper w-scale (in inches) comes under indicator.

Move indicator to arrow (16, v_{min}) in upper w-scale. The minimum film velocity permissible is then read at the hairline in the lower v-scale or V-scale and will be v_{min} = 48 ft/sec or V_{min} = 1920 frames/sec. For 8-mm film the *upper* v-scale and arrow (8, v_{min}) must be used for reading of both velocities, v^* and v_{min}. The minimum film velocity permissible for the same values as in the above example will be 12 ft/sec or 960 frames/sec.

It should be borne in mind, however, that this calculation is based on a permissible image travel of 0.010 in. per frame, with only 0.002 in. image travel during exposure. For cameras with other image travel during exposure time, the location of the arrows (16, v_{min}) and (8, v_{min}), in the upper w-scale would have to be changed.

Value of Slide Rule

For many of the basic computations which must be made by a motion picture engineer, such as evaluations of given film records as well as precalculations for optimum operating conditions of the camera, the above-described slide rule eliminates all numerical calculations.

Of important advantage in perform-

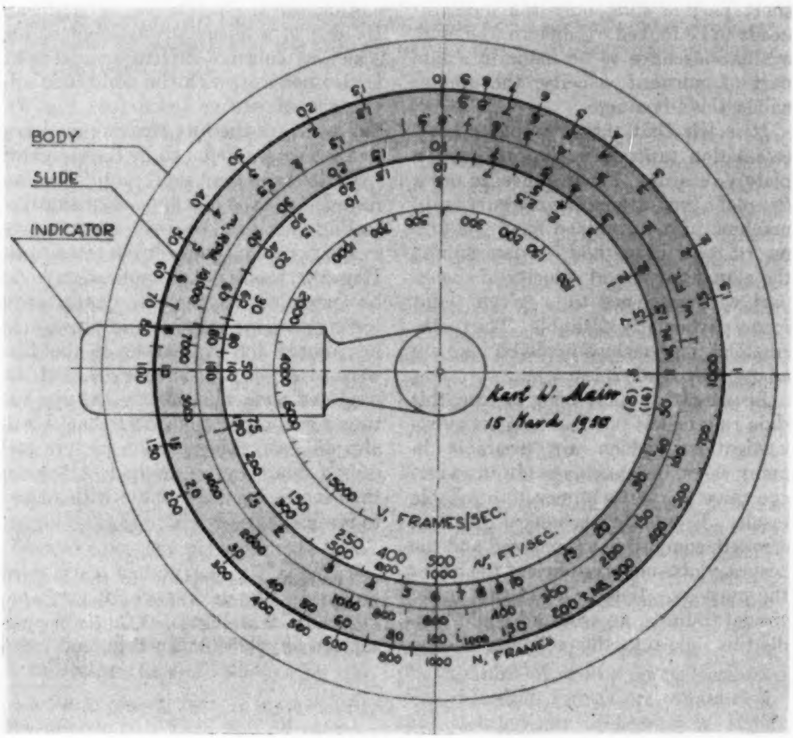

Fig. 7. Model of circular slide rule for analysis of high-speed motion picture films.

ing evaluation tasks by means of a scale is that any length measurements on the film are eliminated. Counting of frames is done simply by visual approximation (for smaller numbers) or by a frame counter (either on the projector or separate), using the frame height as a unit of film length. Measuring of time is done by counting a small number of timing units. In evaluation, the whole film strip is divided into parts of such length that the corresponding film velocity can be considered constant. Due to the constant proportion between length and time within such a short part of film, a definite position of the slide with regard to the slide rule body is prescribed. For evaluations within such a short part of film, only the indicator needs to be moved; therefore, the more evaluations have to be made in a film part of constant velocity, the greater will be this advantage.

It is felt that there are other basic calculation tasks in evaluating motion picture records. For instance, in order to plot time-displacement curves of machine parts, obtained from the film record, a rapid method for determining the actual travel and velocity of such a part with reference to a given point seems particularly desirable. The mathematical relationships involved here are adaptable to slide rule work.

Because of its timesaving feature, this slide rule makes possible long series investigations, which are desirable in many cases, inasmuch as only the average value of a series represents a reliable result. Due to its mechanical function, errors in computing are reduced and the accuracy obtained is sufficient to answer the purpose. It is believed that, after special training, an assistant could handle this slide rule, thus relieving the engineer from time-consuming elementary calculations.

Another use for the slide rule is in calculating optimum operating conditions of the camera prior to taking a picture. It is believed that the present value of the slide rule could be still further increased by adding a scale for the total running time, if more data, regarding acceleration characteristics of different cameras under different voltages, as functions of film travel and time, could be provided. These acceleration characteristics could be obtained by evaluations of film records.

Modification of the present model can be readily effected to include other types of film (35-mm) and timing according to the needs of the engineer. Instead of a linear arrangement of log scales, as shown, a circular arrangement is also possible, with the additional advantage of saving space (see Fig. 7). However, for the first working model, a linear one was found to be the simplest.

Up to the present time, motion picture records are used chiefly as a qualitative testing method, because quantitative evaluations consume considerable time. However, their field of application could be extended to include quantitative testing also, if a suitable and timesaving instrument for evaluation of the film were available. It is believed that the proposed slide rule greatly reduces the time for computations and that it will also aid in making motion picture records a quantitative method of testing, thus increasing their value with regard to mechanics research.

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Use of Image Phototube as a High-Speed Camera Shutter

By Alsede W. Hogan

The image phototube is destined to become an important means of taking good quality high-speed photographs. Its worth has already been proved in several fields. It has a much greater light efficiency than the Kerr Cell. A light *gain* is possible. The angle of view, in contrast to the Kerr Cell, is governed entirely by the lens system used. Relative applications of the device include ultra-high-speed stroboscopes and a versatile color television system. Application of the shutter to very fast multi-frame photography is discussed.

THE IMAGE PHOTOTUBE, or image converter tube as it is often called, first came into prominence during World War II because of its use in the "Snooperscope" and "Sniperscope," which enabled our troops to see the enemy in the dark. It has recently been used in lieu of a shutter in ultra-high-speed photography and, as such, is an important addition to the photographic art. The tube has allied pulsed applications in stroboscopy and television. It may also become more popular in its continuous current applications as an image converter in such fields as spectrometry and photography.

In its operation as a shutter an image is focused upon the photocathode by a conventional lens system. The tube is then energized by a high-voltage pulse which is equal in duration to the exposure time desired. The applied voltage will cause the electrons leaving the photocathode to impinge upon the fluorescent screen and thereby reproduce the image as it appeared on the photocathode. The persistence of the screen will provide an output image of longer duration than the electrical pulse but will not change the effective exposure time so far as the object itself is concerned, because additional electrons do not arrive after the pulse is ended. This persistence is beneficial in most applications because it allows more time for the film exposure.

Photographic Applications

Considerable work has been done in the United States and England on single-frame photography. Dr. Courtney-Pratt of Cambridge University, England, has published some important work in multi-frame and streak photography.[2,3] He has emphasized the photography of self-luminous phenomena. Multiple frames are obtained in this instance by deflecting a small fluorescent image onto various parts of a relatively large screen and exposing the entire area to a single photographic

Presented on May 2, 1951, at the Society's Convention in New York, N.Y., by Alsede W. Hogan, Missiles Division, Naval Ordnance Laboratory, White Oak, Silver Spring, Md.

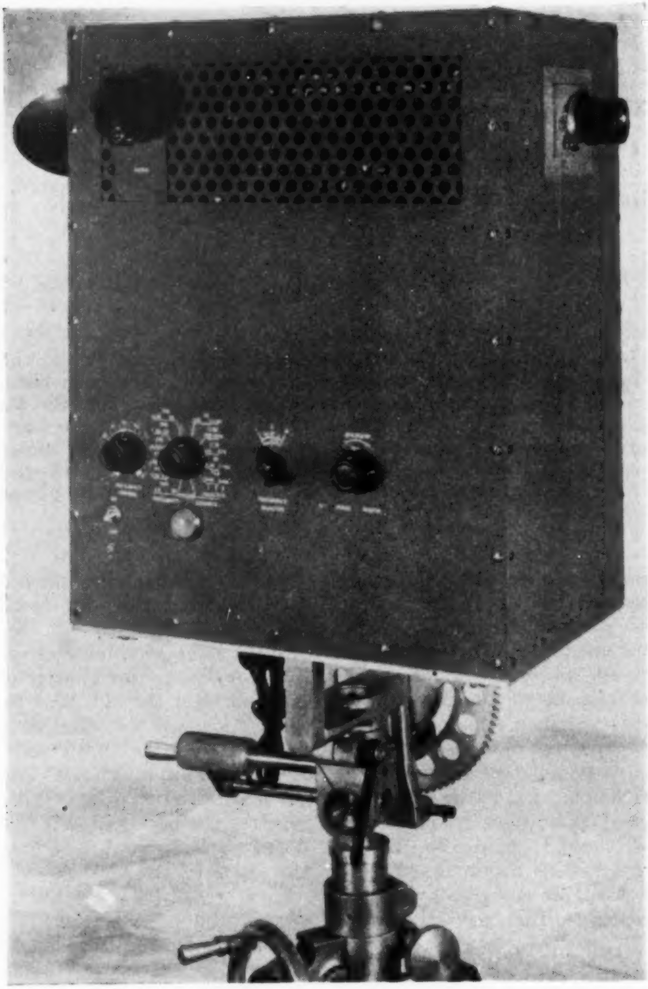

Fig. 1. NOL ultra-high-speed stroboscope.

frame. It is believed that a few frames of the object can be obtained in this manner at a rate in the order of millions per second. It is important to note that the quality of the pictures will not suffer because of the very high frame rate.

Application to conventional types of motion picture photography probably can be easily accomplished. For high frame rates it will be necessary to develop tubes having phosphors with fast decay. P1 and P5 phosphors fall to about 10% of their original brightness in 14,000 and 18 μsec, respectively. Type P15 is faster than either of these. These figures indicate that sufficiently

Fig. 2. Revolving wheel, 2-microsecond exposure.

fast phorphors are presently available; however, some difficulties may arise in their application. For example, it is necessary to have some screens backed with aluminum in order to prevent poisoning by the photocathode material. Most of the tubes available now have P1 (green) screens. It is very likely that the limit upon the frame rate will be determined by the speed with which the film can be moved.

The tube itself can be pulsed much faster than is ever likely to be required for motion pictures, as is evidenced by the NOL (Naval Ordnance Laboratory) stroboscope which has a maximum repetition rate of 300 kc. This value could be increased in the order of megacycles if required. (See Fig. 1.)

Single photographs, utilizing light reflected from the object, have been obtained at NOL with an exposure time of 2 μsec (see Fig. 2). A flashtube having a 2-μsec duration has been photographed at various stages of ionization with ½-μsec exposures. The NOL Explosives Research Dept. has obtained good photographs of explosions with exposure times in the order of 0.03 μsec.

Allied Applications

Stroboscopes using the image phototube can have a much greater repetition rate and a much shorter "on" time than ordinary types. The power consumed by the NOL stroboscope is about 150 watts and does not vary appreciably for repetition rates between 50 c and 300 kc. It can be operated continuously. Such stroboscopes will find important use in ultrasonics, flame studies, and some types of machinery design where the use of flashing lights is impractical.

A color television system using image phototubes is being privately developed by the writer. It is a completely electronic system whereby color intelligence can be imparted to or taken from presently existing systems such as the CBS field-sequential system, the CTI line-sequential system and the RCA dot-

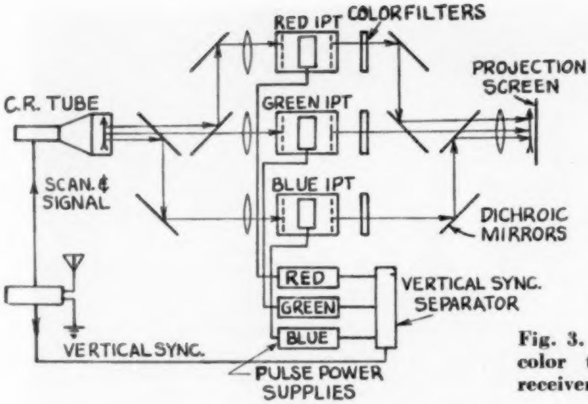

Fig. 3. Image phototube color television system, receiver block diagram.

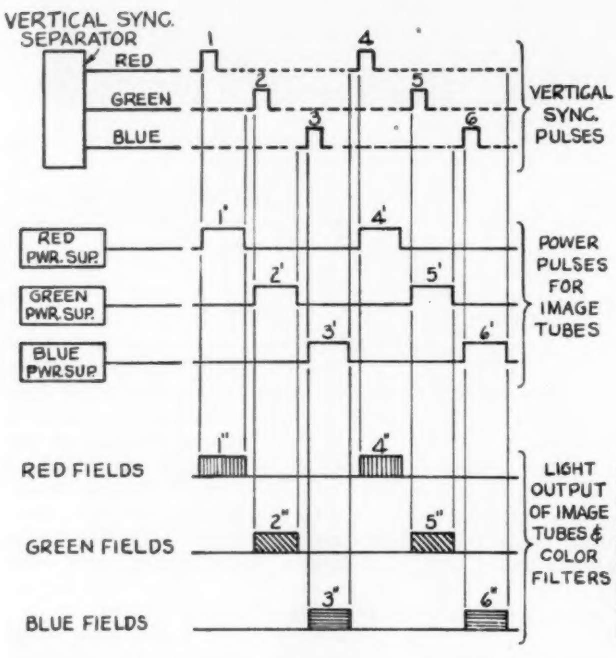

Fig. 4. Pulse sequence for application of image phototube to reception of CBS transmissions. One complete frame is shown.

sequential system. The CBS system will be considered here very briefly. The image phototube system has advantages and disadvantages, but where color television is concerned, any attempt to prove which is superior would be useless as is evidenced by the clash between proponents of various systems. The image phototube system may be used at the transmitting and/or receiving stations. As shown in Fig. 3, the system is all electronic and makes use of

three image phototubes at the receiver, in addition to a single conventional cathode-ray tube of the scanning type. The video signal, which is amplitude modulated in accordance with the primary color light intensities reflected from the object being televised, is applied to the scanning cathode-ray tube. The fluorescent screen of this tube will normally have a white phosphor, although its color characteristic is not critical because the relative color outputs of the image phototubes can be adjusted to the proper levels. The image produced on this tube as a result of conventional scanning is split into three parts by a suitable optical system which is not necessarily color selective. Thus the image on the scanning tube is continuously present on the photocathodes of the three image phototubes. Each of these tubes has a phosphor corresponding to one of the primary colors, or, in lieu of this characteristic, each tube may be equipped with an output color filter corresponding to one of the primary colors. In the latter case, the phosphors would preferably be white. By pulsing the image tubes in a predetermined sequence, as at the transmitter, primary color images arrive at the projection screen and are superimposed upon one another by means of an optical system between the tubes and the projection screen. The superimposition of the primary color images at a rapid rate provides the viewer with a full color impression of the object being televised at the transmitter. The image sequence is presented in Fig. 4.

Tubes

At least three types of image phototubes have been used for photographic purposes. The one easiest to obtain but least suitable for general work of this nature is a British type marked CV148 which is available on the surplus market. This tube has fairly good resolution but will break down on the high voltages required for photographs utilizing reflected light. As is the case with most tubes, the applied voltage can be increased as the pulse width is decreased. Good pictures may be obtained of powder explosions with a pulse voltage between 8000 and 12000 volts and a pulse length of $\frac{1}{2}$ μsec.

The 1P25A has fairly good characteristics except that the fluorescent screen is too small to provide adequate picture detail for large objects. This is the tube used in the American Snooperscope and Sniperscope.

The Mullard type ME1201 has been developed especially for such purposes. The large fluorescent screen should provide very good detail when used in its entirety for single frames. It is also suitable for deflecting smaller images to obtain separate frames at very fast rates.

Data on the last two tubes follow (data for the ME1201 are tentative):

	1P25	*ME1201*
Screen diameter	$\frac{7}{8}$ in.	$4\frac{1}{2}$ in.
Photocathode diameter	$1\frac{1}{4}$ in.	1 in. (effective)
Length	$4\frac{7}{16}$ in.	9 in.
Spectral response	Infrared	Infrared or daylight
Screen fluorescence	Green	Green
Maximum anode volts (continuous)	4500*	6000
Focus	Electrostatic	Electromagnetic
Resolution	110 line/cm	200 line/cm
Infrared conversion factor	0.22 min.	—
Sensitivity (2700 K color temperature)	—	Daylight cathode: 20 μa/L Infrared cathode: 15 μa/L

* About 12 kv for 2-μsec pulse

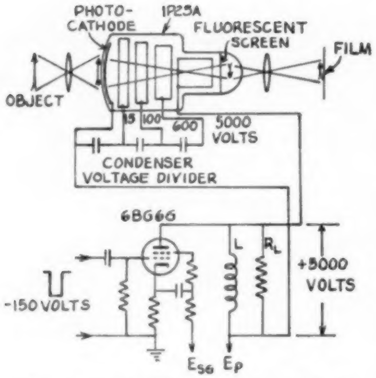

Fig. 5. High-voltage pulse circuit.

Pulse Power Supplies

In the early experiments at NOL the power pulses were generated by discharging a pulse-forming network through a hydrogen thyratron. Later a radar-pulse modulator was used. These methods were satisfactory for single photographs and stroboscopic applications having low repetition rates; however, they involve an extravagant waste of power at high rates because of the low-impedance output characteristic of such devices. To overcome this difficulty, a circuit was designed which is similar to television "fly-back" power supplies. As shown in Fig. 5, this circuit utilizes the energy stored in the magnetic field of an inductance.

In operation, the 6BG6G normally conducts about 100 ma. When it is desired to pulse the image tube, a negative pulse is applied to the grid of the 6BG6G causing its plate current to cut off, forcing the inductance L to discharge through the resistor R_L which consists of several resistors in series to total about 50,000 ohms. The inductance is sufficiently large to maintain a current of approximately 100 ma, through R_L, for the duration of the short negative pulses on the control grid. This current generates a pulse, across R_L, of about 5000 volts, which is a good operating value for repetitively pulsing the 1P25A.

The output pulse would ideally have the same duration and shape as the grid pulse, but this is difficult to obtain on account of the distributed capacitance of the inductance. Pulses in the order of 30 μsec are reproduced fairly well, but pulses in the order of 4 μsec are triangular in shape regardless of the grid input waveform. The pulse time would be most efficiently used if the pulses were square topped at a value of 5000 volts or more. However, for a great many applications, such efficiency is not required. If the pulse is not square the image tube must be well shielded from stray magnetic fields. A slow rising or falling pulse in the presence of a magnetic field results in a movement of the image which makes it appear out of focus on the developed film.

In using high-impedance power supplies, such as the one above, it is essential that the internal capacitance of the image tube electrodes be padded externally to give a proper distribution of voltages; otherwise defocusing will result, i.e., the high-frequency components of each pulse must be taken into consideration. If it is not required that the instrument work on continuous current, for constant viewing, a resistor-type divider will not be required and the padding condensers can be relied on to function as a voltage divider, as shown in the schematic diagram.

Conclusion

It is apparent that the development of the image phototube system has been held up for several years as a result of the absence of suitable tubes. Robert T. Bayne applied for a patent on the basic system in 1943, and it was issued in 1947. Since that time, several persons, including the writer, have independently developed the idea. A growing need for such devices has been responsible for the recent developments.

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Discussion

Emmett Salzberg: I would like to know whether any work has been done on taking normal speed pictures of the screen of a phototube.

Mr. Hogan: There has been some indirect work on that. The limitation on taking motion pictures with these tubes will normally be the decay time of the screens. We now have screens, such as the P5, that will decay to about 10% brilliance in 18 microseconds. This will allow a frame rate of 50,000 per second. The P15 screen has a still faster decay—which puts the limitation of the device on how fast the film can be moved.

Mr. Salzberg: I was mainly interested in normal speed motion pictures.

Mr. Hogan: It should work very well for that. In many instrumentation problems, you will find a great advantage in the fact that it gives ease in synchronization. For example, several cameras, photographing different portions of an experiment, can be *easily* synchronized within a fraction of a microsecond.

Mr. Salzberg: Can you tell us the limiting factors affecting the resolution available from the image converter tube?

Mr. Hogan: Several experts that I have discussed the matter with gave different opinions, based perhaps on different points of view. I have concluded that the electron lens represents the greatest problem and the quality of the fluorescent screen comes next. The photocathode, if any good at all, seems to be better than the rest of the tube.

Kenneth Shaftan: Did Dr. Courtney-Pratt use a German tube and did he get better resolution, for example, than the 1P25A samples shown?

Mr. Hogan: I do not know how well he did with the German tube. He later went to the ME1201 which is supposedly much better; it is certainly better than the 1P-25A that I used.

The New Visual Idiom

By Nat Sobel

One of the most important components of good motion picture production as it exists today is the utilization of special effects and their proper planning. To accomplish the purpose of the advertiser, producer or exhibitor, necessary optical stresses must be carefully planned in television or motion picture work. To that end, we have attempted to set forth reasons why certain effects are used in various ways. The following statements should suggest rather than set the rule for what we think is proper according to the experience which the writer has had.

How many of us ever withdraw from our daily preoccupations long enough to view this art and science of motion pictures and television in a general and objective light?

I have to confess my own shortcomings in this for, after a quarter of a century in film production, much of it in the jungles of negatives and positives, and in the press of everyday technical problems and deadlines, somehow I seem to have missed seeing the picture on account of the footage. And so I shall attempt to assay my first love, my friend and foe alike of many years—the optical or special effect. Perhaps a review of opticals as we know them today will bring us some understanding of why they are now universally accepted as a mature medium of visual communication.

What a vexing problem the optical effect can often be. Yet so firmly is it established in modern production, so expanded, so refined, that I'm sure we can think of it, without qualification, as a new visual idiom.

Classification

This new idiom may be classified into four specific categories: the fade, the dissolve, the wipe, and what is known by that rather nebulous and somewhat catchall term, the montage.

This new idiom provides coherence and continuity to a film story. It opens and closes a sequence, it punctuates the narrative, it permits a graceful transition from sequence to sequence, even from scene to scene.

The Visual Idiom

The idiom, as associated with language, is the product of natural growth. It originates to supplant an existing form, or to fill a need. And gradually, because of its convenience, its effectiveness, its superiority, the new form gains broadened usage until it is fully integrated and accepted as part of the language.

Presented in May 1947 before the Atlantic Coast Section meeting by Nat Sobel, Cineffects, Inc., 115 W. 45th St., New York 19, N.Y.

Such has been the history of the optical effect. The dissolve, for example, since its invention by the French cinema pioneer, George Melies, has risen from a singular display of genius to an integral pattern woven into the fabric of every worth-while film production. And, similarly, since the days of D. W. Griffith and the fabulous "Billy" Bitzer, it has been standard practice to begin a film with a fade-in and end it with a fade-out. We do this with an authority equal to the one that tells us to begin a sentence with a capital letter and to end it with a period.

Not too many years ago opticals were regarded as anything but an accepted idiom. They were viewed more or less as a spectacular vernacular. And yet we have only to analyze one of today's professional films to realize how thoroughly opticals have been integrated into the language of the cinema and of television, particularly in the commercials, where opticals are now a mainstay.

Today it is the rule—not the exception—that every film designed to alert and hold the attention of an audience must be laced together with intelligently planned and professionally rendered special effects or opticals. While the average viewer is rarely conscious of the actual techniques, he nevertheless feels their presence—or absence—without identifying them.

The Fade (Fig. 1)

The grandaddy of all optical effects is, presumably, the fade. In essence, it is a device used to represent a pause in the pictorial flow of the narrative. The fade means either "cessation of action" or "inauguration of action." Properly used, the fade is to a screen play what the curtain is to the theater. The fade-in raises the curtain, the fade-out lowers it. The fade supplies intrasequence transition.

Technically, the best fade is the most even fade. There are two ways to execute fades. One is to use a gradual reduction or increase of light, controlled by a rheostat. The other is accomplished by closing or opening the camera shutter from 0° to 170°. Although both methods are effective, our personal preference is the latter. Especially is this true in shooting color, since light controlled by resistance tends to affect the color temperature of the light source, resulting in a not too faithful reproduction of the original.

The Dissolve (Fig. 1)

The dissolve is a device that effects transition *within* the framework of a sequence, or *between* sequences, when there is to be no pause in the flow of the film.

For instance, suppose we want to show the progress of a young chap from the time he is inducted into the army until the time he goes into battle. We have, let us say, scenes of our protagonist enlisting, being examined, receiving his uniform, in training, embarking, landing, marching to the front, and finally in battle. Assuming that none of these scenes are ends in themselves, we could link them together with dissolves for transitional purposes and thus maintain a definite and uninterrupted pace. The battle scene, on the other hand, would probably be an end in itself and so we would end it with a fade.

The dissolve has been called—and with ample reason—the most significant of all cinematic and televisual discoveries. It has myriad uses, many of them basic to the production of a convincing picture. Its extreme value is worthy of illustration by another hypothesis.

Let's assume we have a man—we'll call him "Lefty"—approaching a building and that we wish to move him inside and show him at work robbing a safe. Suppose there were no such thing as a dissolve. We would have two alternatives. One, we might expend the time and footage to bring Lefty into the building, up the elevator, along the corridor and into an office. The alternative

Fade *Dissolve* *Wipe*

Figure 1

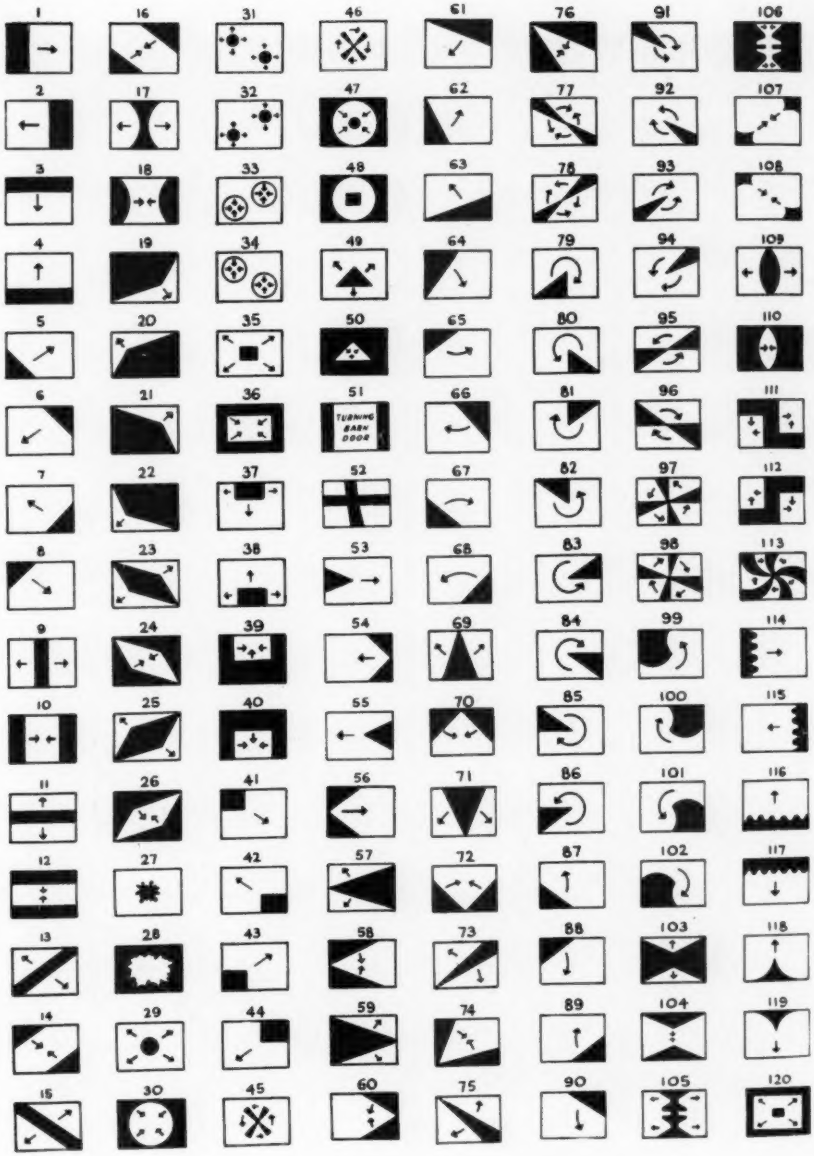

Fig. 2. Graphic outline of a variety of optical wipe effects, reproduced from a chart made by Cineffects, Inc.

96 79 6

Fig. 3. Trailer and television wipes.

9 29 1

Fig. 4. Feature, or production, wipes.

would be to straight-cut from exterior to interior, and thereby give the audience the impression that they are watching a jet-propelled Superman.

Of course, the proper way to make the transition is to use the dissolve.

A dissolve is nothing more than a combination of a fade-out and a fade-in. The measure of a good dissolve is the equilibrium of density, and of highlight and shadow, between the two shots used. Experience teaches us that the best dissolves are achieved when we do not use the same length of shot on both sides of the optical center. Flush dissolves, which call for the opening and closing of the shutter to a full mathematical 170° during the time of the effect, are practical only when the dissolve is made between two shots that have identical backgrounds.

The Wipe (Fig. 1)

Figure 2 shows graphically the many types of wipes which are generally used. The wipes illustrated in Figs. 3 and 4 are correlated by number with those on the chart (Fig. 2).

The wipe is an optical device used to represent simultaneous action.

Here we have Michael playing golf, and we wipe to a scene of his wife Jacqueline at a tea party. By this action we infer, visually, that Jacqueline is having tea while Michael is playing golf. The dissolve usually infers succeeding action, whereas the wipe infers contemporary action.

The psychology behind the use of many wipes in trailers and television spots is apparent when we consider that the purpose is to show that there are distinct advantages in seeing the film or buying the product being advertised, because of the number of exciting and interesting situations happening in the film or a number of superiorities in the advertised product, situations or advantages which the patron can't afford to miss. The wipe is used to heighten this impression, to plant the idea that all these wonderful things are simply bursting through the sprocket holes, occurring almost simultaneously.

Wipes are executed by means of film or metal mattes. In our optical department we have developed more than 120 types, each one of which is capable of producing an unusual and individual type of effect. Trailers and television spots usually employ the more bizarre wipes, usually with sharp edges, which are calculated to give impact. In features, however, the principal types used are soft, the common types being right to left, left to right, diagonal and vertical. (See Figs. 3 and 4.)

The Montage

The montage offers the most fascinating possibilities in this new visual idiom. And, although superimposition, split screens and similar techniques have enlivened some pictures which would otherwise have creaked through, montages themselves have often mounted pictures to such powerful climaxes that no ordinary narrative could hope to keep abreast of them.

An accurate definition of a montage is difficult. It has come to mean almost everything from superimposed scenes, double exposures of various kinds, and split screens, to a series of short shots dissolving into one another.

The most fascinating aspect of the montage is the ability to burst the bonds of time and space (Figs. 5A and 5B), and even reason, and still to remain entirely credible. When we see the picture of a bullet superimposed over a shot of a turning globe which may even be combined with that of a ship at sea with the waves breaking over its bow, we do not pause to question this violation of time and space. The appeal of the montage is wholly emotional. We feel that the montage—this magnificent, yet almost entirely unexploited device—offers to producers an effective transition and to television advertisers a brand new cinematic dimension. (See Figs. 5A and 5B.)

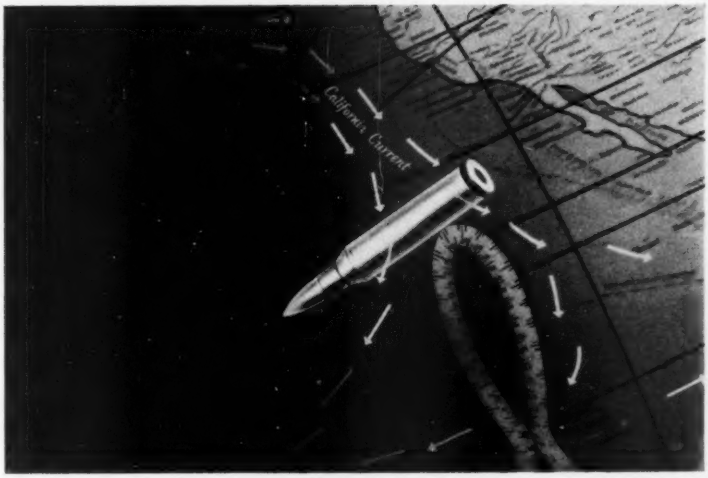

Figure 5A

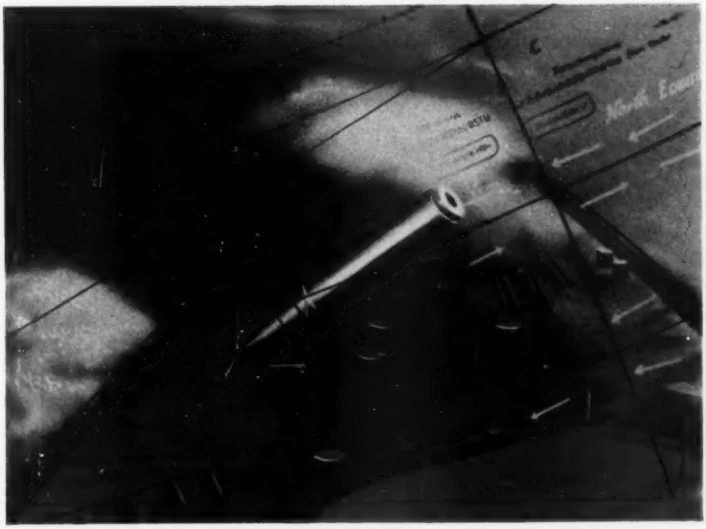

Figure 5B

Time-lapse montage illustrating superimposition over split screen.

Planning

It is our belief that the motion picture in television is an accepted medium of expression and that a major reason for its acceptance is the new visual idiom. The maturity of the optical techniques brings an additional element of responsibility, particularly with respect to the care and forethought the producer should put into planning them. The time for planning is *before* photography is started.

A typical instance where proper forethought spelled success in the end occurred in a production where the script called for bullets emerging from a machine gun in action. Even tracer bullets, we know, are barely visible in daytime, so that a special technique had to be worked out in advance of shooting.

We worked out the following procedure: The machine gun was anchored and photographed in action during the daytime. Then, the same gun was photographed in action at night, using tracer bullets which were visible as they emerged from the barrel in the darkness.

It was possible then to literally matte out the superfluous exposure in the second shot, and superimpose it over the daylight shot, at the same time dodging out the superfluous exposure of the sky in the first take. The net result was visible bullets emerging from the machine gun (Fig. 6).

Advanced planning cannot be overemphasized. There are good shots for wipes and dissolves, and bad shots. The best dissolves are made in the mind, not in the camera. The day is past when a producer gathers an assortment of shots and bundles them off for "suitable" opticals.

Titles

The average movie or television fan has come to expect that a picture will open with smart titles over an interesting background. He senses that the main title fades in, that credit titles dissolve into each other, and that an optical is used to mark divisions between titles and picture.

The modern producer devotes considerable time and thought to the creation of striking and symbolic main titles—the pictorial overture. They are calculated to arrest the eye, awaken interest and set the mood for the film that follows.

Innovations in the field of title work call for ingenuity in the title department. Let me sketch for you the techniques we used for a recent production. This type of title treatment is in common usage not only in motion pictures, but also in television commercials.

Our storyboard calls for the superimposition of white titles, with black shadows, over a live-action scene. The scene shows black buildings on a snow-covered landscape. The technical problem is to retain white titles against the snow. (See Fig. 7).

In this instance, since the live action is an inherent part of the desired effect, our problem is more complicated.

First, we render our lettering in white on a glass panel, drawing in the offset black shadows on the opposite side of the glass to give the illusion of depth.

We begin photography by bipacking a fine grain of the live-action shot, with negative stock. Our camera photographs the black shadows of the lettering acting as a matte over a white card, thereby resulting in a dupe negative (undeveloped, of course), of the scene with letters.

Next, we rewind the negative stock to starting mark previously made on the raw stock. We then photograph the lettering over a black card after first removing the fine grain. Now the shadow of the lettering is lost in the dark background and the white lettering itself is heavily exposed over the previously duped live-action scene. Thus, we arrive at the desired result, a duplicate negative of the live action over which is superimposed, in perfect regis-

Fig. 6. Composite matte shot.

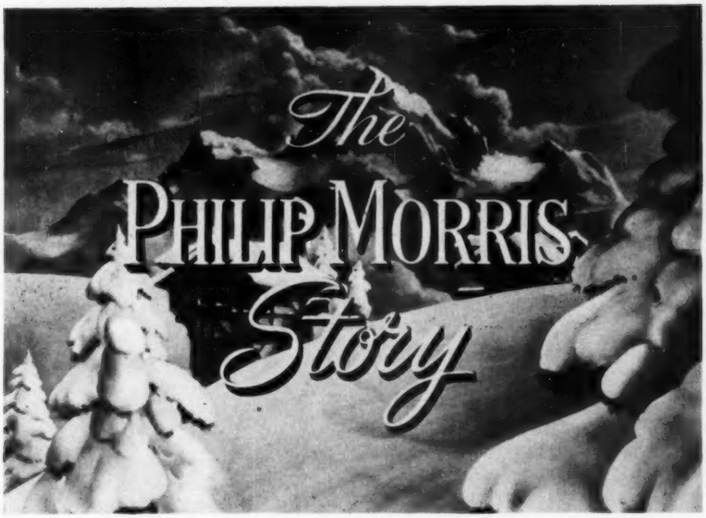

Fig. 7. Title, illustrating enhancement of white letters over predominantly white background.

tration, the white title with the black shadow (Fig. 7).

A further complication arises if the titles must move, as, for instance, when there is a considerable amount of copy. Only a pan title serves the purpose. In such a case, the previously described operations take place, but the letters and shadows are moved according to minute calibrations, accurately determined, depending upon the reading time necessary for comprehension. A photographic technique is utilized, to which we refer as "stop-motion," (frame by frame exposure), a necessity because of the extreme accuracy required in matching the position of both exposures of the lettering and shadows in action.

Television

Whatever importance you are inclined to attach to our new visual idiom with respect to motion picture productions, should be doubled for television.

We have found in our organization that we should never begin shooting without a prior conference of department heads. Nine times out of ten these discussions turn into involved debates on optical treatments. We find that when the various components—live action, animation, stop-motion, etc.—*are preplanned*, they come together in a smooth, optical integration of the segments, a composite of an effective, workable commercial.

We find, too, that optical effects are no longer confined to the optical bench. On our animation stands, in particular, much hard thinking on the part of the camera supervisors—plus the unusual gadgets we have developed—makes possible many of the special effects so necessary for television spots.

Films employing these effects enjoy a psychological advantage. From the very first frame the audience senses that it is in for a treat, one that comes only from a highly original job, professionally executed.

Acknowledgments

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Special Techniques in Magnetic Recording for Motion Picture Production

By George Lewin

Several modifications in standard magnetic recording systems which provide greatly improved operating efficiency as well as economies in time and materials are described. These include facilities for: (1) stopping and reversing recorder and projector without losing synchronism, and (2) changing over from Record to Playback, or vice versa, silently, while running. These facilities make it possible to correct errors in narration and re-recording jobs without need for rethreading, splicing or blooping the film. Also described is a new method for domestic and foreign lip-synchronous production which makes use of 35-mm magnetic loops.

The Signal Corps Photographic Center was one of the earliest, if not the earliest, user of magnetic recording for motion picture production work. As soon as the availability of 35-mm magnetically coated film was announced it was recognized that here was a new medium which offered possibilities for effecting tremendous economies in the use of photographic film and its attendant processing costs. Steps were immediately taken to design an attachment for existing optical-type film reproducers, to permit the recording and reproduction of magnetic sound tracks. An RCA Fantasound type of film reproducer was fitted with an erase and record head and was in successful use for recording and reproducing narration tracks as early as 1947 (Fig. 1).

It was quickly realized, because of the scarcity of magnetic film stock at that time, that it would be undesirable to cut up the film for the purpose of editing out errors in the narration, thereby losing one of the main advantages of magnetic recording, namely, the ability to use the stock over and over again and thus reduce its actual cost to the vanishing point.

Standard Procedure in Photographic Recording

Before the advent of magnetic recording, the normal practice in recording narration tracks for motion pictures was to use regular photographic film, and to record "wild," that is, without picture, and make numerous retakes to obtain the desired inflections and timing. The negative would then be developed and printed, and the print sent to the cutting room where considerable editing would have to be done to cut out errors, splice

Presented as the first of two papers on May 4, 1951, at the Society's Convention at the Hotel Statler, New York, By George Lewin, Chief Recording Engineer, Sound Branch, Signal Corps Photographic Center, New York.

in the corrections, and juggle sentences back and forth to obtain the desired timing. In spite of the high cost of this procedure, the final result often left much to be desired because of the noise introduced by excessive handling of the film, the splices, and the inherent noise of film processing.

Magnetic recording appeared to offer the possibility of eliminating most of these problems. Our reasoning was somewhat along the following lines:

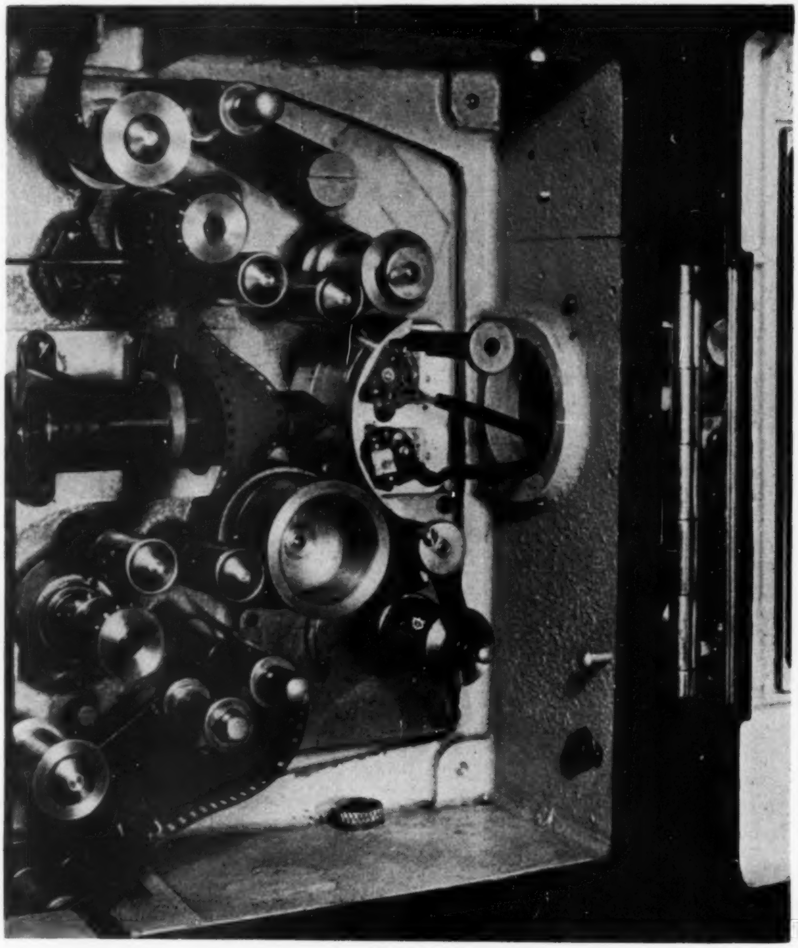

Fig. 1. Signal Corps Photographic Center modification of RCA Fantasound Reproducer showing magnetic erase and record heads set into curved aperture plate.

Requirements for Synchronous Narration of Magnetic Film

Suppose we had a medium which would allow us to stop both picture and sound track if the narrator made an error, back up ahead of the point at which the error was made, then run forward again, correcting the error and proceed onward, all without losing synchronism, and without leaving any telltale bloops or noises. If we could do all these things, we would really have a major improvement in production technique. Not only would we have a perfect narration track ready for immediate use, but we would also have eliminated completely the use of photographic film, its processing, editing, and the attendant cost and time. The fulfillment of all these requirements obviously presented a number of formidable problems, but these were all solved in due course, as improved projection and recording equipment became available and were modified to meet our special requirements.

Modifications for Reverse Drive

The projector (Fig. 2) was equipped with an additional belt coupled to the upper feed reel, which acted as a take-up when the motor was reversed. The intermittent movement of the Century projector head is capable of being driven in reverse with no particular precaution other than reducing the tension of the pressure plate.

The Westrex 1231 type of magnetic recorder (Fig. 3) was fitted with a special take-up and feed assembly which was designed especially for us by Westrex, and which runs equally well in either direction. Figure 4 shows a front view of this recorder.

The 3-phase interlock type of motor distributor system in use at the Signal Corps Photographic Center lends itself to the requirements of running in either direction, while maintaining perfect synchronism at all times, including starting and stopping. A separate bank of motor outlets is provided at the motor patch panel (Fig. 5), and connected to the regular distributor bus through a relay. This relay reverses one pair of rotor and stator leads by remote control from a push button at the distributor start position, which also has incorporated with it the controls for switching from Record to Playback. A foolproofing relay is included which makes the reversing button inoperative until the system has come to a complete stop. Thus, the main distributor motor and its synchronous drive motor always run in the same direction, but only the projector and recorder motors are reversed, which simplifies the wiring problem. (A recent modification now also permits the projection-type footage counter to be reversed, without interfering with the remote control reset feature.)

Figure 6 shows a close-up of the control panel, which is built into the mixing console. The procedure in stopping is to open only the third phase of the main phases to the distributor system, so that all motors can be stopped "in phase." Then the reversing button is pushed, the third phase is closed again, and the system started up once more, with the projector, recorder and footage counter now running in reverse. When the proper picture or footage cue is seen on the screen, the system is again stopped in phase, the reversing button is pushed again, restoring the original polarity, and the system is ready to start rolling in the forward direction. The entire operation takes less than a minute because usually it is necessary to back up only 20 or 30 ft to correct an error.

Figure 7 shows the control panel in relation to the mixing controls. The motion picture screen is visible through the window of the monitor booth.

Modifying Recording Circuits

The biggest problem was to modify the magnetic head switching circuits and the bias and erase oscillator, so that the

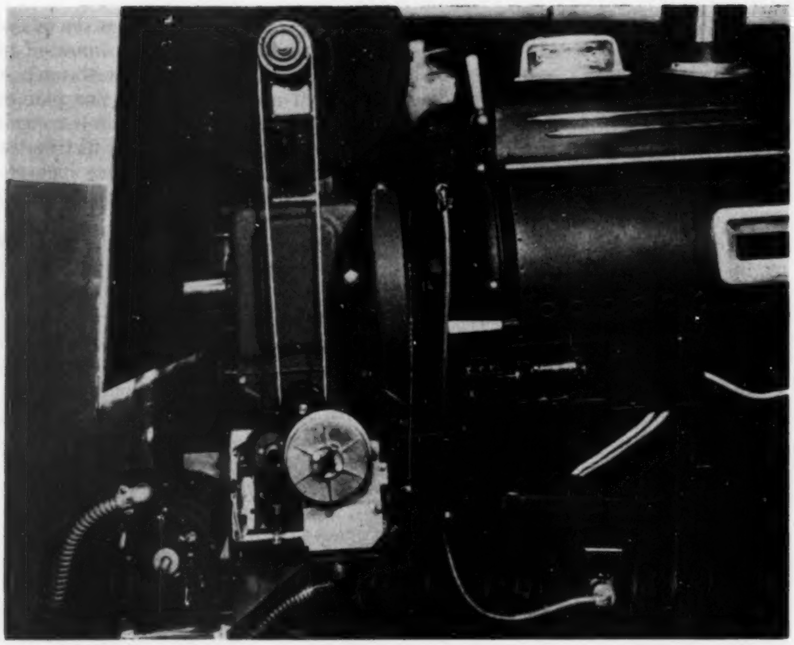

Fig. 2. Projector equipped with belt to provide take-up in reverse direction.

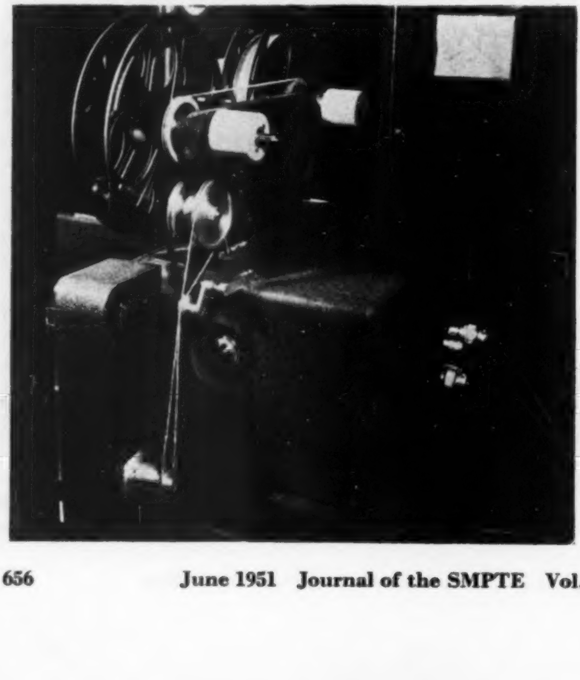

Fig. 3. Rear view of Westrex 1231 Type Magnetic Recorder equipped with special reversible take-up; also additional belt drive for Signal Corps Photographic Center loop magazine.

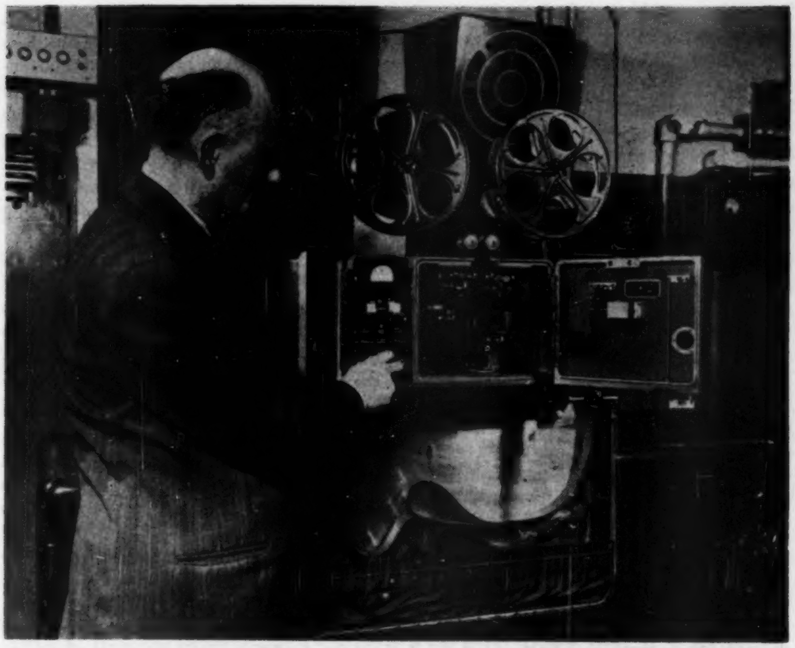

Fig. 4. Front view of Westrex 1231 Type Magnetic Recorder loaded with reels for reversible operation. The glass-door loop magazine is built into the base of the recorder.

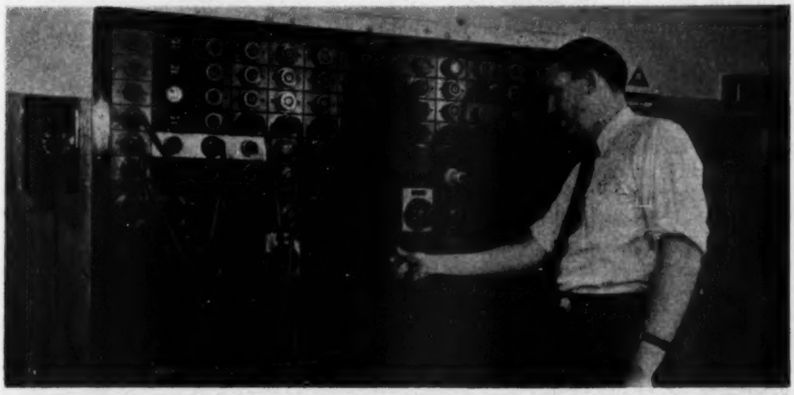

Fig. 5 The motor patch panel. The receptacles which are wired through the reversing relays are indicated by distinctive colors, as are the start positions which have reversing facilities.

transition could be made from Playback to Record with the film running, and yet have absolutely no bloop or click appear on the track. Conversely, in switching from Record back to Playback, which would be necessary if it were desired to insert a corrected paragraph in the middle of the reel after it had been completed, it is required that the end of the newly recorded track be blended into the old one without a bloop.

There would be no point in showing the exact circuit we use since each type of equipment has its own problems, but the general conditions which have to be met are as follows:

(1) The use of a separate playback head is not desirable, because this causes an unavoidable time delay. A single head should be used for both Record and Playback, with appropriate switching.

(2) A single key should be provided, with three positions: Record in one direction, Playback in the opposite direction, and a neutral position in the center.

(3) The bias and erase oscillator should be of a type which provides a separate oscillator tube followed by a driver stage and output stage. This permits the output to be controlled by the voltage on the driver stage, while the oscillator tube operates continuously, so that no trouble is encountered due to frequency shifts.

(4) When throwing the key from Playback to Record, the head should immediately switch from the input of the playback amplifier to the output of the recording amplifier. After a short delay, approximately ¼ sec, the plate voltage is applied to the driver stage of the oscillator, which should be arranged so that bias and erase currents build up gradually in about ¼ sec.

(5) When throwing the key from Record to Playback, the bias and erase currents should be allowed to die down gradually (in about ¼ sec) and then 1 sec later the head should be switched from the Record amplifier to the Playback amplifier. In other words, the important consideration, in effecting quiet transitions from Playback to Record, is to be sure that the head is switched before the bias currents build up; while, in going from Record to Playback, the bias currents must be allowed to die down gradually before the head is switched.

This last precaution, incidentally, insures against the possibility of leaving the head in a magnetized state.

(6) The neutral position of the key is utilized to keep the playback circuit open momentarily while switching from Record to Playback, so that no bloop is heard in the monitor speaker while the bias currents are collapsing.

Correcting Errors in Narration

When the system has been stopped because of an error, and the film is backed up, the sound just recorded is heard reproduced in reverse, and the picture is seen moving backward on the screen. This helps in spotting the cue at which to stop backing up. After stopping, the system is run forward again, and the playback is heard. As soon as the proper cue is reached, the switch is thrown back to Record. The narrator is then given the cue, and by the time he starts to talk, the bias current is up to its normal value.

After the reel has been completed, it is played back with the picture for checking. At this time it is often found that some error has been overlooked, and it then becomes desirable to insert a corrected sentence or paragraph. This can be done smoothly and quietly, as already described. The only additional precaution to be taken is that the inserted paragraph is not longer than the one being replaced.

Explanation of Demonstration Recording

At this point in the Convention presentation a sound recording was run to demonstrate the complete silence of what might be called the "magnetic splices" made by this technique.

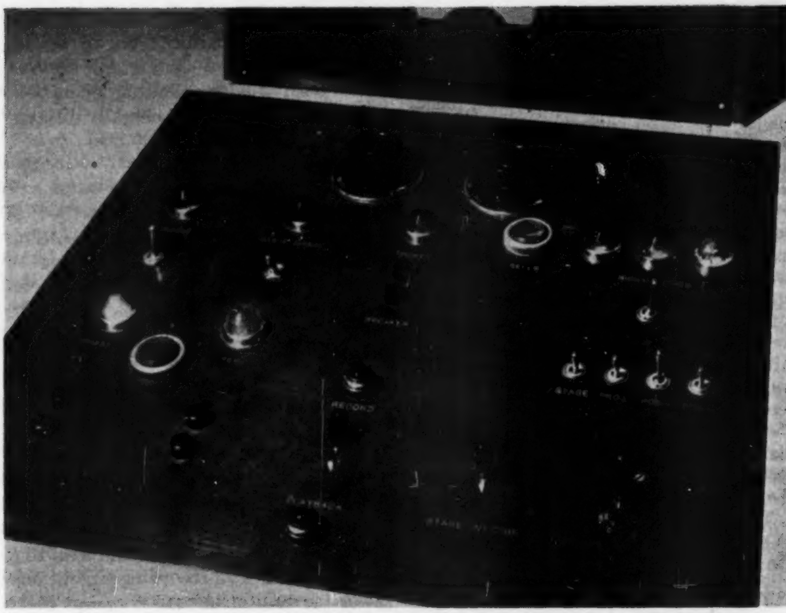

Fig. 6. Remote control panel which is built into mixing console. Complete reversing facilities, as well as switching between Record and Playback, are available.

Fig. 7. The control panel in relation to the mixing controls. The motion picture screen is visible through the window of the monitor booth.

The procedure used in recording this demonstration was to read one complete sentence and continue part way into the next sentence. The system was then stopped, as though an error had been made. The mixer backed up the film into the middle of the previous sentence, and then ran forward in Playback position. As soon as the last word of the sentence was heard, the mixer went into Record position, and the narrator proceeded to read the next sentence completely, and halfway into the following sentence. This operation was repeated for each sentence—a total of twelve sentences—so that there were actually eleven magnetic splices. After the recording was completed in this way, the sixth and seventh sentences were reread, separately, while the mixer inserted them into the record in place of the original sentences, as though they were corrections which were found necessary after the recording was completed.

The actual sound track projected was a 35-mm direct positive, re-recorded from the original magnetic film.

This system has proved successful beyond all expectations. For one thing, we find the narrator does a much better job because he can be more relaxed, knowing that if he makes an error no particular harm is done. He also does not have to keep going if he feels himself getting tired or tense, or wants to clear his throat. He simply stops and rests a moment, while we back up a little way and get ready to proceed again.

The system has proved especially valuable on rush projects, of which we have had a great many since the start of the Korean crisis. For example, Staff Film Reports, which are weekly summaries of latest battle reports made for high echelon review in the Pentagon, are narrated in the morning by this method. Immediately upon completion of each reel of narration it goes into the re-recording room, where it is mixed with the necessary music and sound effects, and transferred to the release negative, all within the space of a few hours. By the old method, we would either have to wait for the narration track to be developed and edited, or else mix the live voice with the re-recording operation, which is a difficult and generally unsatisfactory procedure.

Re-recording Operations

The technique above described is equally adaptable to all re-recording procedures as well as re-recording to sound tracks for certain types of television productions, such as newsreels. In fact, it should be adaptable to any type of production which requires the rapid assembling of narration with other sound tracks.

In the case of re-recording operations, it is entirely feasible to back up an entire bank of reproducing machines along with the magnetic recorder and projector, and we have plans for doing this in the near future. This will mean that in complicated re-recording operations, where several errors are very apt to be made in a reel, it will be possible either to correct these errors as we go along or to insert the corrections after the reel is completed, whichever happens to be more suitable. This is obviously superior to the usual procedure of doing over a complete reel because of one or two errors.

Of course, we already do all our re-recording operations on magnetic film first, and then transfer the OK take to photographic film, so that no film is ever wasted because of errors. This has been standard practice now for over two years. In this process, as with the reversing process, we have also found that there is a greater smoothness of operation and a reduction in tension on the part of the mixers, because they know that an error does not mean a waste of film. In fact, it is customary to make a magnetic recording on what would ordinarily have been a rehearsal by the old method, and it is often found that the rehearsal is a perfectly good take.

Magnetic Loops for Lip-Synchronous Operations

Another application of magnetic recording, which is still under development but will soon be in operation, is in the type of production known as foreign adaptation, or lip synchronization (lip sync for short). This is the operation in which a completed English version of a production is provided with a new sound track in which a foreign language has been substituted for the original version. Where actual dialogue is involved, the translation to the foreign version is made with a view toward having the foreign words match as closely as possible the actual syllables of the English words. The recording of this translation then becomes a very exacting process, wherein the speaker must synchronize his words as closely as possible to the actual lip movements of the person on the screen; hence, the term lip sync.

This procedure is also often used to replace original recordings by a new sound track in English, when the original is not usable due to bad pickup conditions, or to some trouble having developed in processing. Certain location jobs are often deliberately shot without sound, or with a cue track only, because of impractical pickup conditions and the sound is added later by the lip-sync process. All of the following remarks would apply equally to English and foreign lip-sync operations.

Procedure in Photographic Recording

The usual procedure throughout the industry is to break the picture down into a large number of short loops and project each of these repeatedly while an actor speaks the foreign words and attempts to match his lip movements to those on the screen. Several rehearsals are made, followed by a number of takes on film. The percentage of NG takes is usually rather high, resulting in unavoidable wastage of film. In an effort to reduce the wastage, it is customary to print several takes and combine the best portions of them. This entails considerable work in the cutting room, and infinite care on the part of the editors to accomplish a smooth job, free from noise due to handling and splicing of the film. Since considerable NG footage must be developed and printed, the process is rather costly, but this was unavoidable before the advent of magnetic recording. In any event, the process is still much more economical then reshooting the entire picture for foreign release, or making retakes where original English is involved.

Procedure for Magnetic Loops

Tremendous reduction in cost is anticipated by the use of recording on magnetic loops. Instead of breaking the picture down into loops of assorted sizes, all the loops will be cut to a few standard lengths, down to an exact number of sprocket holes. This can easily be done by adding blank leader when necessary. A number of magnetic loops are then made up to these exact sizes. The recording machine is equipped with a loop magazine, which permits convenient handling of the loops (Fig. 8). With this method it is easy to make as many takes as necessary in order to get as nearly perfect a take as possible, without wasting a single foot of photographic film. As soon as a good take is obtained, it can be played back immediately in synchronization with the picture, and as many times as desired, without even the need of stopping the film. If it is adjudged a good take, it can be immediately transferred to a photographic recorder which is always standing by ready to roll, right alongside the magnetic recorder.

In this way, the editor receives only OK takes from the laboratory, and needs only to splice them together in proper sequence to make a complete sound track. Bloop marks can be recorded from the projector in the usual way to aid in proper synchronizing.

The photographic film and its processing are thus reduced to an absolute minimum. It is conservatively estimated that film and processing costs can be reduced at least 75% by this method, while the reduction in working time in the cutting room is even greater than this.

The use of photographic film can even be eliminated completely, at this point, by re-recording the OK loops to another magnetic recorder, and assembling the completed reel by cutting the magnetic film. Moviola equipment is already available for doing this, but it has not been used as yet because of the relatively high cost of the 35-mm tape. Besides, we have plans for accomplishing this on ¼-in. synchronous tape, which would be more economical of both material and storage space. This will be touched upon in the next paper, on ¼-in. synchronous recording.

Explanation of Demonstration Film

At this point in the convention presentation a reel was run to demonstrate the result of a lip-sync operation using a magnetic loop.

A sequence from the standard SMPTE theater test reel was selected because of its familiarity to the audience. The sequence was 100 ft long, and, with the leader, made a loop 111 ft in length. While such a long loop would rarely be necessary in practice, it was used here to demonstrate that it can be done. Moreover, the great length of the loop made it possible to demonstrate that after looking at the Playback, and deciding which parts were good and which were not, it was feasible to retake the bad portions, while preserv-

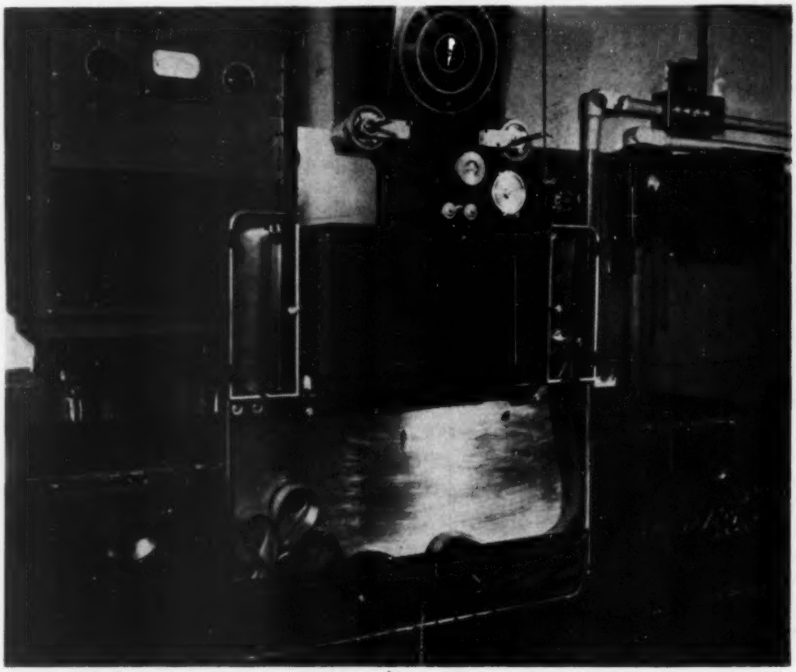

Fig. 8. Magnetic recorder threaded for loop operation.

ing the good portions. Thus, the technique for making corrections in narration is combined with the technique of using magnetic loops. The result is the production of long sequences of lip-sync without the need of editing, other than the simple transfer of the completed loop to a photographic negative for making the composite print.

Simplified Procedures

Another innovation which is being planned to simplify the lip-sync operation is to eliminate completely the use of a monitor room. We have installed facilities for doing the mixing and remote control directly on the narration stage. This means, of course, that no monitor is heard during the actual take, but the selected take is immediately heard on the playback speaker. In this way, the actor, director, mixer and script clerk become a closely knit crew without the need for an intercom system and a separate monitor room, thus simplifying and speeding up operations. Even the recording machines can be placed in a glass-enclosed booth which we have on the stage, within sight of the rest of the crew, resulting in even better coordination of the operation. Only the projection machines would remain isolated because of their high noise level.

In closing, it is desired to acknowledge the efforts of: James J. Kennedy, Jr., Chief, Transmission Section; Norman Kessel, Chief, Projection Section; Steven Szeglin and M/Sgt Sanford Hanscom, of Transmission Section; all of whom made valuable contributions to the successful completion of the work described in this paper.

Discussion

William Jordan: When you back up how do you eliminate the NG material?

Mr. Lewin: Before you start backing up, you throw over to Playback. That, of course, is essential otherwise you would be erasing and you might erase the wrong thing. So you hear the material in reverse and you also see the picture on the screen with everything moving backwards. That helps you to know just where to stop. Then you stop and run forward, still in Playback, so you're hearing the last part of the OK sentence. As soon as you reach the end of that sentence, the narrator gets his cue to start talking and you go into Record, erase whatever is NG on the film and substitute the correct dialogue.

Dr. E. W. Kellogg: One wonders whether this same system can be applied to correcting errors in tapes while photographing.

Mr. Lewin: Well, I suppose you could, but after all there is nothing you can do about the picture when they make a flub. Some day when we have electronic means for recording the picture, you will undoubtedly be able to erase the picture as well and correct them both.

Joel Tall: How fast can you make the change from Play to Record without getting the sharp erase wavefront?

Mr. Lewin: The actual speed that we use is approximately a quarter of a second although we haven't made any tests yet to determine whether we can shorten that. I rather suspect we can make it quite short, but what we used in this particular setup came out about a quarter of a second. As you noticed in the demonstration, there isn't any appreciable lag between the end of one sentence and the beginning of the next, even though we had to go through the procedure of throwing the key before each sentence.

(*All photographs for this paper are U.S. Army photographs.*)

Synchronous $^1/_4$-In. Magnetic Tape for Motion Picture Production

By George Lewin

Synchronous ¼-in. magnetic tape can be used in various stages of motion picture production. With proper modifications of existing commercial equipment, ¼-in. tape can be made to do practically everything possible with 35-mm sprocketed magnetic film. Savings in cost and storage space can be more than 90%. This new technique is equally valuable for producing motion pictures for television.

The many advantages of recording on 35-mm magnetic film are, by now, well recognized and practically undisputed. There is, however, one disadvantage in 35-mm film, and this applies to photographic as well as magnetic, namely, the fact that the sound track, at the most, need be only about ¼ in. wide; the rest of the film is wasted. In the case of photographic film, there is not much that can be done about this fact. The only solution that has been offered is to use both edges of the film, but this, at best, cuts the cost only by half, and it also introduces new problems. If the film is slit down the middle before using, it requires modifications in the recording equipment, and also in the developing and printing equipment. If it is not slit before using, there is the ever-present danger that the recording on the first side may be ruined by some accident while the second side is being recorded or printed. Also, an accident during processing would do just double the damage. In the case of magnetic recording, there are similar objections to double or multiple tracks, including the impossibility of editing the film.

Presented as the second of two papers on May 4, 1951, at the Society's Convention at the Hotel Statler, New York, by George Lewin, Chief Recording Engineer, Sound Branch, Signal Corps Photographic Center, New York.

Relative Costs and Space Requirements

If we had a satisfactory means of obtaining synchronous operation with ¼-in. tape, we could take advantage of the lower cost and smaller space requirements inherent in this medium. In fact, the savings in cost and space amount to over 90% for ¼-in. tape in comparison with single-track recordings on 35-mm film. In other words, in applications where we might want to edit the tape and, therefore, could use only single-track recordings, and could use the tape only once, the cost of ¼-in. tape, at a recording speed of 15 in. per sec, would be only about 20 cents per minute, as compared to $4.00 per minute for 35-mm tape, a ratio of 1 to

20 in cost. In terms of storage space, we could store at least two hours of recording time on ¼-in. tape in the same space required for 10 minutes of recording time on 35-mm film, a ratio of 12 to 1.

It is, therefore, obvious that any possibility of adapting ¼-in. tape to our recording needs should be thoroughly explored.

Possible Uses of Synchronous Tape

Some of the possible uses of ¼-in. tape are:

(1) The straight synchronous recording of all stage and location recordings.

The simplest and most immediate way to do this would be to record all takes on ¼-in. tape, using slapsticks for synchronizing. Only the selected takes would then be transferred to regular photographic film for editing. All of the takes would be held on the tape for protection, until the picture is completed. Relatively little space would be required for this and the cost would be negligible, as the tape could be reused.

(2) The synchronous recording of all composite music and effects tracks for foreign versions.

This material is now held on 16-in. discs. quarter-inch tape would be more economical for this purpose, because it could be reused, and the fidelity would be higher, especially for very low-level effects.

(3) All important re-recordings made to photographic release negatives for answer prints could also be duplicated and preserved on ¼-in. tape. The cost of doing this would be low because the tape could be reused after answer-print approval, and the storage space would be low. It would be desirable to do this, because if additional release negatives were required, they could be made by re-recording from the ¼-in. tape with better fidelity than by duping from a photographic master. On the other hand, it is not practical to store 35-mm tape for this purpose because of the high space requirement.

(4) All valuable music and sound effects libraries can be preserved with higher fidelity and in less space by re-recording to ¼-in. tape.

The present method of preserving libraries in 35-mm negative form is wasteful of space, and the negatives deteriorate rapidly with each printing. Much better dubbing prints can be made by re-recording from the ¼-in. tape to 35-mm direct positives, or still better, to 35-mm magnetic film, or to synchronous ¼-in. tape. This latter method would relieve the laboratory of a considerable workload.

(5) All new music and sound effects can be recorded originally and preserved on ¼-in. tape.

(6) All film-strip narration tracks can be recorded originally on ¼-in. tape for re-recording to disc masters. This is already being done at the Signal Corps Photographic Center.

(7) When suitable ¼-in. synchronous editing equipment is available, many of the re-recording operations now done with 35-mm photographic tracks could be done directly with ¼-in. tape tracks.

(8) When a lip-synchronous project is being done by the magnetic-loop process, described in the previous paper, the 35-mm loops could be transferred to ¼-in. tape instead of to photographic film. This tape could then be edited and used for the final re-recording, thus eliminating completely the use of photographic film and its processing, except for the release negative.

In view of this large number of possible applications for ¼-in. synchronous tape, it was deemed advisable to devote considerable time to the study of equipment available for this purpose, and the possible modifications which could be made to adapt it for our particular needs.

Methods for Synchronizing

Several methods have been devised for obtaining synchronous operation with ¼-in. tape. Such systems have been described in past issues of the JOURNAL,[1,2,3] but none of them offers the complete flexibility possible with 35-mm sprocketed film used in conjunction with interlock distributor, as described in the previous paper. However, a system which used automatic framing control came closest to the type of flexibility desired and was selected for further study and possible modification to meet our particular requirements.

The automatic framing control makes it possible to play back a tape recording in synchronization with a picture, once a start mark has been established on the tape. This is very useful for certain applications, such as the broadcasting of television recordings, but it was not immediately adaptable to use with our interlock type of distributor system. However, with the cooperation of the manufacturer's engineers, several modifications have been made which have greatly improved its usefulness for motion picture, as well as television, production.

Special Requirements for Synchronous ¼-In. Magnetic Tape

Our requirements, which were not met originally by any existing ¼-in. tape equipment, are as follows:

(1) The recorder must be capable of automatic remote starting and stopping, together with the distributor system.

(2) It should be possible to place a start mark on the tape prior to recording, and then use this same start mark for the playback. In other words, it should not be necessary to hunt for a start mark after the recording has been made. This is an important requirement if the recorder is to be used on rerecording operations, where alternate recordings and playbacks are necessary in rapid succession.

(3) It should be possible to make straight synchronous recordings (without automatic framing control) and re-record them to a synchronous photographic recorder, without the need of alternately clamping and unclamping any mechanical devices inside the machine.

(4) It should be possible to switch from Playback to Record, and back to Playback by remote control, without stopping the tape. This feature is necessary to permit the correction of errors in narration, as we do with 35-mm tape.

(5) It should ultimately be possible to operate the recorder with the framing control in either forward or reverse directions, and maintain synchronism with the distributor system at all times. This is recognized to be a very severe requirement, but would have to be achieved before it could be claimed that ¼-in. tape can do anything that 35-mm tape can do.

The Advantages of Interlock Over Synchronous Systems

An explanation should be made at this point of the reason we favor the use of an interlock distributor system over a straight synchronous motor system, which is used in some other studios. We list the following reasons:

(1) We have never been fully convinced that a straight synchronous system is capable of exact synchronism, if we define this term as plus or minus zero frames. In order to get a synchronous motor up to speed, in exactly the same length of time each time that it is started, it must be a generously oversized motor and it must be unaffected by changes in load conditions due to temperature, line voltage changes, and various conditions of binding in the machine, especially in the case of projectors.

(2) The sudden starting of a machine repeatedly is certainly bad practice from a maintenance standpoint, es-

pecially if you are dealing with a large number of delicate and expensive machines, such as re-recorders and projectors.

(3) With a straight synchronous system, it is certainly impossible to stop, and run backward and forward, without losing synchronism.

The interlock distributor system eliminates all of these objections.

The Fairchild Synchronous System

No attempt will be made to describe fully the theory of operation of the system we selected for further study, as this has been done adequately in a paper already published in the JOURNAL.[2] Suffice it to say that 60-cycle intelligence is recorded on the tape, as a control track, along with the program material. This control track is actually a 15,000-cycle carrier modulated by 60 cycles from the line, so that it can be recorded and reproduced by the same heads as the program, but separated by appropriate filter circuits. The tape itself is transported during recording at exactly 15 in. per sec by a capstan, which is locked to the synchronous motor drive, and which permits no slippage of the tape. During playback, this synchronous lock is disconnected mechanically, and the capstan is puck-driven at a ratio which, in the absence of any other control, would drive it at about 2% above synchronous speed. However, the 60 cycles from the control track is picked up by the playback head, separated from the program by appropriate circuits, amplified, and fed back to one phase of a two-phase control motor, which is also coupled through pucks to the capstan. The other phase is powered by line frequency. This control motor is poled so as to slow down the capstan to approximately synchronous speed. The actual control circuit functions on a phase basis so that stability is achieved when the 60 cycles from the control track matches the 60 cycles from the line, both in frequency and phase. By this method, the tape is always reproduced at a speed which corresponds to exact synchronism with the line frequency, regardless of stretch or shrinkage which may have developed in the tape during the time elapsed between recording and playback. Any slight slippage between tape and capstan during playback is also compensated for by this method.

The Automatic Framing Control

The automatic framing control is an accessory device, which was originally intended to permit playback of the tape in synchronism with a projector. It provides a means for slowing up the starting time of the tape while the projector catches up with it, and then automatically switching over to synchronous operation after normal speed is obtained. It makes use of two small selsyn motors, one of which is coupled to the projector and the other, through a differential gear, to the tape capstan.

Modifications in Fairchild System

With this very sketchy description of the theory of operation in mind, we will now consider the adaptations which have been made to meet the requirements enumerated above.

(1) To provide automatic remote start and stop with our distributor system, a separate interlock motor is provided which is geared to a small selsyn motor. This is shown at the right of the recorder in Fig. 1. This selsyn motor performs the same function as the one which is coupled to the projector in the original application of the Fairchild equipment. A relay is also provided which turns on the a-c power to the tape recorder the moment the distributor starts running. (Both the selsyn motor and relay are in the small black box attached to the left end of the interlock motor.) The framing control then takes over until normal

Fig. 1. Synchronous ¼-in. tape recorder and accessory equipment.

The framing control unit is directly above the recorder. The interlock motor (which is ordinarily out of sight in an accessory cabinet) is seen at the right with the small black box attached containing the selsyn motor and tape-starting relay. The remote control boxes, seen in front of the interlock motor, can be extended on cables as far as desired. The motion picture screen is visible in the background. (*U.S. Army photograph.*)

speed is reached, when it switches over to synchronous operation.

(2) In order to make it possible to place a start mark on the tape before recording, and to use that same start mark when making the playback, it is necessary to use the automatic framing control when recording, as well as when playing back, instead of on the playback only, as originally intended. This posed an interesting problem, since the framing control depends upon the presence of a control track to tell it when to revert to synchronous speed. It was believed at first that the track being recorded at the moment would serve this purpose, but this proved to be a fallacy.

The control circuit ordinarily depends upon detecting the difference in frequency between the control track being reproduced, and the line frequency existing at the time of playback, and then reducing this difference to zero. If the playback head picks up the control track which is being recorded at that moment, there is no difference in frequency even though the tape speed is not normal, and the result is that the capstan stabilizes at a speed about 2% slower than synchronous speed. If an attempt is made to play back a recording made in this way, it is found

that the control system does not have enough control to hold the tape down to this speed, and it occasionally slips out of synchronization.

The most practical way to overcome this problem would be to install a mechanical means of locking the synchronous motor to the capstan at the moment the framing unit relinquishes its control. However, since this would have taken considerable time to design, a simpler solution was sought in the meantime. This resolved itself into installing a relay in the framing unit which disconnects the control power at the moment the framing unit gives up control. It was found that the mechanical drag of the control motor, coasting along, was just about sufficient to hold the capstan at approximately synchronous speed during recording. During playback, of course, the regular control power is automatically restored by the same relay, so that the tape is reproduced at exactly the same speed at which it was recorded. Thus, exact synchronism is maintained.

(3) In order to avoid the need of locking and unlocking the mechanical coupling between the synchronous drive motor and the tape drive capstan when changing from Record to Playback, a relay has been installed which performs the same function as the one just described in connection with the automatic framing control. This relay is installed within the recorder itself so that it functions even though the framing-control unit is not used. The control motor is left coupled to the tape capstan at all times, so that no change has to be made between Record and Playback other than to operate the usual control switches.

(4) In order to provide means for switching back and forth between Playback and Record without stopping the tape, it was only necessary to by-pass the fool-proofing circuit, which is purposely included in the standard machine to minimize the possibility of erasing recorded material accidentally. The control for this facility is provided in a small box at the end of a long cable, so that the mixer can control this remotely, besides starting and stopping the machine. The reversing is still done by the operator at the recorder, but it is planned to make this a remote control also.

At the present time this facility is used for nonsynchronous recording only, as it has not yet been definitely established that the replacement of one control track with another can be done without occasionally losing synchronism. A probability factor is involved here, depending upon whether the new control track is in phase with the old one, or possibly gains or loses more than half a cycle. If necessary, a method can probably be devised to insure that the new control track remains in phase with the old one.

(5) In order to achieve facilities for running in reverse with the framing-control unit, additional relays and some circuit changes will probably be necessary. Complications may also arise from the fact that, in reverse, the playback head, which picks up the control track, precedes the point at which control is applied to the driving capstan; whereas the control system was designed to work the other way around. The achievement of this facility would be very desirable, as it would break down the last barrier against complete equality between 35-mm and ¼-in. tape for motion picture and television production.

It might be appropriate at this point to discuss briefly the method we have used to check the accuracy of synchronism of our ¼-in. tape recording tests. The obvious method of photographing someone speaking in front of a camera is not very accurate if we are interested in detecting small errors in synchronism, such as two frames or less. Besides, many speakers have a disconcerting

type of lip movement which makes them look out of synchronism even on a live television show. The cost of photographing and printing is also a drawback. The method we have adopted is to record a voice simultaneously on 35-mm and ¼-in. tape recording equipment. The two tracks are then played back in synchronism, with the outputs mixed together. In this way deviations of even one sprocket hole are instantly detectable, and no photographic film is used. Even the voice can be eliminated and replaced by a loop having a series of clicks. By this method we have verified time and again that the system will remain in perfect synchronism continuously for complete 33-min takes.

Of course, it is not to be inferred from this that we consider an error of one sprocket hole to be serious, but it should be borne in mind that errors may accumulate in the same direction during the various steps of production, and if they add up to two frames or more they can become very disconcerting, and detract from the realism of a production.

Explanation of Demonstration Film

At this point in the Convention presentation a film was run to demonstrate the result of lip-synchronizing a number of loops by a combination of the methods discussed in this and the previous paper. This film was made in the following manner:

A number of typical picture loops were obtained and cut to exactly equal lengths by adjusting the leaders. A 35-mm magnetic loop was cut to this same length. Two projectors were used so that, as soon as one loop was completed, rehearsals could be started on the next one without delay. The actual procedure was to keep recording on the magnetic loop until a good take was obtained. This was immediately played back with the picture—which can be done by this method without the need for even a momentary stop. If the take was not considered good enough, additional ones were made immediately. If it was good, it was transferred immediately to the synchronous ¼-in. tape, and at the same time the next loop was started up for rehearsals.

The actual time consumed from the time the first loop started rolling until all of the selected takes were transferred to ¼-in. tape, was possibly a half-hour, which would determine the cost of the narrator's time. Of course, after this point, because we do not yet have professional-type editing equipment for ¼-in. tape, we spent considerable time editing the tape into one continuous length to match the picture, which also had been reassembled into one piece. But when this had been accomplished, it was necessary only to make a single transfer to 35-mm photographic film, using up only the exact amount of film as the completed project, instead of at least five times the amount of negative and print which would be necessary by the conventional method, to say nothing of the editing time required to juggle words back and forth to obtain the required perfection of synchronism.

Before closing, mention should be made of some of the disadvantages of ¼-in. tape, because it is not our intention to leave the impression that it is ever going to supplant 35-mm completely, in the foreseeable future. The most important disadvantage is probably the complexity of the synchronizing system, relying as it does on delicate electronic circuits, and the accurate reproduction of a relatively low-level control track. The control system also causes some increase in flutter content.

Another disadvantage is the frailty of ¼-in. tape. It is more easily damaged by rough handling and is easier to snarl up in rewinding than is 35-mm film.

A third disadvantage is the unfortunate tendency of ¼-in. tape to permit leakage of the magnetic image to adjacent layers of the roll. This "print-thru" effect apparently has not bothered radio broadcasters very much, but in motion picture narration, where there are numerous blank intervals between isolated sentences, there is often heard a distinct, though faint, anticipation of

the first few words of a sentence during the preceding blank interval. This is usually not noticed by the average audience and should not be classed as a serious disadvantage. It is likely, however, that further research will eliminate this effect.

In spite of these few drawbacks, it is to be hoped that the many other great advantages will encourage the increasing use and development of this medium for motion picture and television production.

In conclusion, appreciation is expressed to Wentworth Fling and Larry Saper of the Fairchild Recording Equipment Co., and also to Abraham Seidman of our Sound Branch, for their cooperation in making the modifications described in this paper.

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Discussion

John Frayne: I think this is the first instance where we have had a comparison of the sprocket-hole film versus the tape. We have had the protagonists for both sides who have made claims, and I think this is a very interesting contribution to the literature. I'd like to ask one question: Do you foresee in the near future an extension of this synchronized tape to general motion picture production such as we have in the larger studios?

Mr. Lewin: Yes, I really do. In fact, I, for one, am trying very hard to push the application of this system because I feel that we can save so much film and so much time in the usual intermediate processes that go on before the picture is ever released; and I am convinced that we can certainly maintain synchronism. That is the least of our problems. I think the biggest problem now is professional-type editing equipment, so you can do a smooth job when you edit this tape and that is something which will have to be learned by the personnel. The people that are accustomed to working with 35-mm film are generally antagonistic to playing around with this dinky little tape, but I think that's just a matter of getting accustomed to it.

Col. Richard H. Ranger: I didn't want to ask a question. I just wanted to thank Mr. Lewin for giving us an objective in this work, and for setting up the various merits of the two systems. We should see what we can do to meet the challenge that he has given us on quarter-inch tape.

New Video Recording Camera

By F. N. Gillette and R. A. White

The camera described has been designed specifically for video recording purposes, and therefore differs in many respects from the usual conception of a 16-mm camera. To accomplish intermittent film pulldown within the short space of time available, a multiple skip claw movement is utilized. The usual mechanical shutter is eliminated, but a device is incorporated to actuate an electronic shutter, which at the same time provides for the transition from 30-frames/sec television to 24-frames/sec film speed. In order to obtain the necessary film stability at the aperture, and to eliminate any tendency to scuff or wear off film emulsion at this point, a vacuum-operated film gate is utilized, which permits the camera to be operated for rather long uninterrupted periods of time. Provision is made within the camera for the simultaneous recording of sound, at standard spacing for correct sound synchronization.

VIDEO RECORDING, being a relatively new art, presents many new problems. For obvious reasons of economy, 16-mm film is used almost exclusively. However, the equipment used in the process must have the professional quality and ruggedness previously available only in the 35-mm field. Although the camera operates at standard frame rate, the pulldown time must be extremely short, and a transition from 30-frames/sec television to the 24-frames/sec film rate is required. It is also necessary that the camera be capable of operating without interruption or attention during recording of a half-hour or even full-hour program. In addition, provision must be made for recording program sound simultaneously with the picture, in correct synchronization.

A contribution by F. N. Gillette and R. A. White, General Precision Laboratory Incorporated, Pleasantville, N.Y.

This new camera has been designed specifically for video recording, with adequate provision for the foregoing requirements.

Method of Operation

Before describing in detail the camera's design and construction, it is necessary to describe briefly the basic method of recording for which this camera was intended. Figure 1 is a diagram showing one possible time relationship between television fields, recorded film frames and film pulldown. The diagram shows that one half of a television field is discarded during pulldown for every two full fields (or one full television frame) which are recorded. Since the picture to be photographed appears as successive lines on the face of a cathode-ray tube, some means of preventing film exposure during pulldown must be incorporated. This might be an accurately timed me-

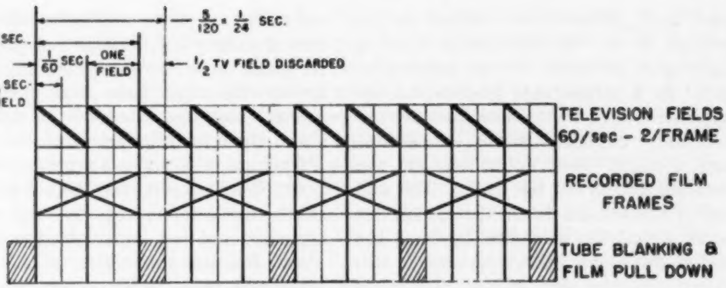

Fig. 1. Timing diagram, illustrating transposition from 30-frames/sec television to 24-frames/sec film recording.

chanical shutter, or it might be a so-called electronic shutter, by means of which the cathode-ray tube is blanked out during pulldown. The latter method is the one used with this new camera, as is the time cycle illustrated. Referring to Fig. 1 again, it will be seen that since the television fields are continuous, the specific moment at which a film frame starts is immaterial, the main requirements being:

(1) that the electronic shutter remain open for the length of time required for a full television frame and no more, and

(2) that pulldown action and shutter action are correctly timed with respect to each other, as in the case of the normal mechanical shutter.

Further study of the time diagram indicates that the time available for pulldown is that of one half of a television field, or 1/120 sec. However, this full time is not available in actual practice for several reasons, the major one being persistence of the cathode-ray tube phosphor. Because the picture is put on the face of the cathode-ray tube in the form of lines, one after another, the film in the camera is exposed to the maximum decay time of the first line only, and to each succeeding line of that frame for a uniformly decreasing length of time. Unless the film is permitted to remain in the aperture for a reasonable period after the last scanning line appears and the electronic shutter closes, a very definite density difference, or splice line, is apparent, marking the join-up of the first and last portions of the frame. This problem of picture splice is treated in detail in a paper by F. N. Gillette.[1]

In addition, a more comprehensive treatment of the electronic shutter and the associated equipment is available in another article by F. N. Gillette, G. W. King and R. A. White.[2]

General Description

Figure 2 is a picture of the complete camera with all doors closed and lens and film magazine in position. The door used in normal operation is the one toward the front of the camera, with its latch indicated at point 1, while the door to the rear half can be opened whenever necessary for access to the modulator.

The magazine shown is a standard 16-mm magazine of 1200-ft capacity, manufactured by J. M. Wall, Inc. Its take-up pulley is spring-belt driven from a simple friction clutch located within the camera housing.

The lens mount accepts the Eastman Cine Ektar lens, and the one illustrated and normally supplied is of 40-mm focal length and has a maximum aperture of $f/1.6$.

The power "on-off" switch mounted in the camera base is indicated at point 2, to the left of which is the "power-on"

pilot light, followed still further to the left, at 3, by the film-break warning light next to which is the fuse-holder cap. In a comparable position on the opposite side of the camera base are the necessary electrical cable connectors, and a small hose connector for the vacuum supply to the gate. The end bell of the camera motor can be seen at point 4, but the threading knob on the end of the motor cannot be seen in this view. On the rear of the camera at point 5 is the exit port for use with continuous processing equipment. The window for the footage counter is also located in the back wall near the exit port, but is not visible in this view.

Figure 3 is a close-up view with operating door open, showing the film path in detail. At point 1, the film is pulled out of the magazine and forms a loop before it enters the film gate at point 2. At point 3, it forms another loop as it leaves the film gate and continues around the drag sprocket at point 4. From there, it follows around the scanning drum at 5, under a tension roller at point 6 in a tight loop and then it is taken up at point 7 by the upper sprocket and fed back into the magazine. Point 8 shows the roller on the automatic stop device which functions in case of film breakage.

All castings are of aluminum alloy, shafting is stainless steel, wherever practical, and double-shielded prelubricated ball bearings are used throughout. All gearing is steel mating with laminated phenolic, with the exception of the motor shaft gear which is nylon.

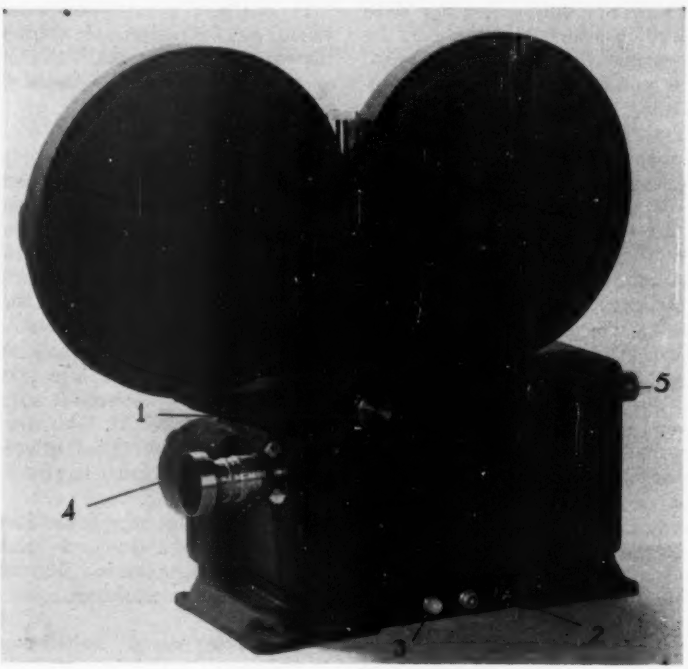

Fig. 2. Complete video recording camera.

Intermittent Design

The one-half field or 1/120 sec maximum available pulldown time, translated into degrees, results in a figure of 72°, which is not an exceptionally fast pulldown. In practice, however, because of the phosphor persistence effect previously mentioned, it is necessary to decrease this time to less than half of the theoretical maximum.

A claw-type intermittent is used, the main components of which are a vertical cam, two lateral cams mounted on a single shaft, plus the claw or shuttle. The lateral cams are rotated at 1440 rpm or once per film frame. The front lateral cam actuates the claw in a forward direction for engagement with the sprocket holes of the film just prior to pulldown. The rear lateral cam actuates the claw in the opposite direction to disengage it at the end of pulldown. Since these cams are both mounted on the same shaft and rotate once per film frame, there is one claw entry and one retraction per film frame. The vertical cam which, as the name implies, actuates the claw in an up-and-down

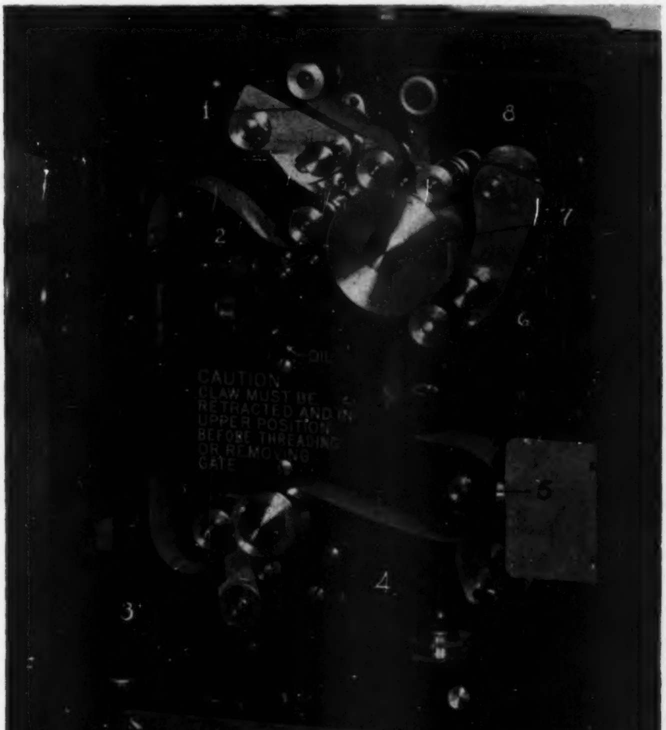

Fig. 3. Interior view of camera, showing complete film path. The vacuum-actuated film gate can be seen between the upper and lower film loops, and notes on threading appear on the cover of the intermittent housing.

action, is timed with the lateral cams through a pair of 3-to-1 ratio helical gears, and is rotated at three times frame speed. As a result of this multiple-skip design, the claw makes three excursions up and down per frame, one out of every three downward excursions being used for pulldown. A high-speed pulldown is thereby obtained, while shaft and cam speeds remain uniform.

The actual pulldown time is one-third of the vertical cam angle (⅓ of 85°), or 28.5°. Allowing some time for claw entry and retraction, the total time during which the claw is in contact with the film is in the order of 31°. The difference between the aforementioned 72° and the latter 31° is the time available for the film to remain stationary in the aperture after the last scanning line appears, and thereby approach equalization of exposure to the phosphor's decay before the next pulldown occurs.

It was previously determined by experiment that movement of the film within the aperture in excess of 0.00007 in. (which is 0.025% of aperture height) during exposure would result in a noticeable pairing of picture line structure. It was believed, therefore, that even the most accurate register pins, entering or leaving the film during exposure, would cause more film movement than could be tolerated. Therefore, since there is not sufficient time available before or after pulldown to actuate register pins fully, they are omitted.

The camera is powered by a 3600-rpm hysteresis synchronous motor, which drives the vertical cam shaft at 4320 rpm. Since it is difficult to retain oil or grease on the cams at this high speed, a wick lubrication system is incorporated. The wick continuously wipes the vertical cam surfaces, keeping them sufficiently lubricated. This, incidentally, is the only part of the camera requiring frequent replenishment of lubricant. Vibration is kept to a minimum by dynamically balancing both intermittent shaft assemblies, all cams and the motor armature. The items are individually balanced so that, in case of field replacement, balance is still maintained.

Shutter Action

The electronic shutter, as such, is not a component part of the camera, but rather a part of the associated electronic equipment. The camera opens the electronic shutter by delivering to it a correctly timed electrical pulse. Thereafter, the shutter remains open for a full television frame, its closing being controlled by its own circuitry.

The timed electrical pulse is obtained by means of a light source, a light aperture, a photocell and a rotating disc. The rotating disc, known as a "pipper" disc, since it produces pips or pulses, is mounted on the vertical cam shaft, at the opposite end of the shaft from the cam. It thereby rotates at three times frame speed (or 4320 rpm) and being 4 in. in diameter, has a high peripheral velocity. Near the periphery of the disc is a small radial slot, about $\frac{1}{16}$ in. wide and $\frac{3}{16}$ in. long. Adjacent to the pipper disc is a member of the camera gear train, which rotates at ⅕ frame speed and has five holes equally spaced around its periphery. Designated as the cycling gear, it overlaps the pipper disc so that the slot in the disc and one of the holes in the cycling gear rotate into line once per frame. From the light source, through a light aperture on one side of this assembly, a light pulse is impinged on a photocell located on the opposite side. The pulse occurs each time the slot in the disc and a hole in the cycling gear rotate into line with the light aperture. The high peripheral velocity of the pipper disc produces a steep wavefront pulse of short duration, while a pulse repetition rate of once per frame is obtained by the masking of the cycling gear, without which there would be three pulses per frame. The angular relation between the vertical cam and the slot in the pipper disc determines the time re-

lation between film transport and shutter opening.

As previously mentioned, no motion of the film in the aperture can be tolerated during exposure, therefore the claw must be free of the film before the shutter opens. The camera is timed, therefore, to open the shutter the moment the claw is free of the film at the end of pulldown.

Figure 4 shows the removable assembly consisting of photocell and pipper lamp, designed for ready removal and rapid replacement of either photocell or pipper lamp. Replacement of either does not disturb shutter timing, and can be done in a matter of seconds, without the necessity of shutting down the camera, should either fail during operation.

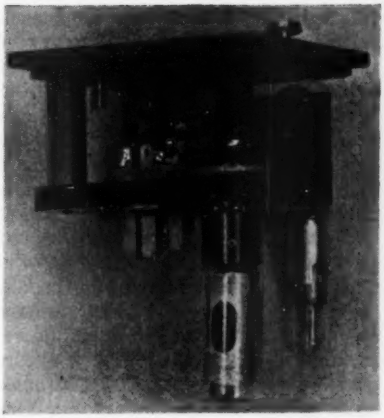

Fig. 4. "Plug-in" assembly of photocell and pipper lamp. Note coin-slotted captive screws which anchor assembly in place on camera.

Film Gate

During the early development stages of this camera, the usual spring-loaded pressure shoe was used in the film gate to hold the film in the focal plane in contact with the aperture plate, and to obtain the necessary film friction in the gate.

However, it was believed that if another means could be developed which would provide the necessary film friction during pulldown and retain the film securely at the aperture during exposure, without introducing sliding contact pressure on the emulsion surface of the film, long-time operating conditions would be more favorable. This led to the development of the vacuum-actuated film gate now in use in this camera.

The front half of this device contains the aperture plate, side guide rollers at top and bottom, and a spring-retained shoe supporting the film against the claw during pulldown. The use of a spring-retained surface to back up the film is a desirable safety feature. Should the claw lose registry during a stand-by period, the spring permits the claw to ride over the film during the first pulldown stroke until it picks up the perforations. If there was a solid backing at this point, the claw, once out of registry, would tend to make its own perforations, and would not immediately get back into correct index. It should be understood, however, that the claw does not normally lose index with the film, but because there are no register pins, it can do so if the film is accidently moved within the gate during a stand-by period.

The rear half is the hinged part of the gate, and is held closed (or open for threading) by a toggle-action device. A rigidly fastened vacuum shoe replaces the usual spring-loaded pressure shoe directly behind the aperture in this rear half. When the gate is closed, there is a total of about 0.012 in. clearance between the surface of this vacuum shoe and the aperture plate. The vacuum shoe is a rectangular steel plate, about 1 in. wide and ¾ in high. Its center portion, which is centered behind the aperture, is relieved for a depth of 0.010 to 0.015 in. over an area corresponding to the picture. This surface is finished with a flat black lacquer. The rest of the shoe surface is lapped and

polished. Above, below and along each side of the image area is a series of small holes, connected to a continuously evacuated chamber just behind the vacuum shoe. When the film is in position for exposure, it tends to seal the vacuum holes and is thus held firmly in position in all directions. The vacuum holes in the area of the sprocket perforations, however, are so spaced that as pulldown commences, the vacuum is partially relieved by the film perforations passing over these holes and opening the vacuum system to atmospheric pressure. But as pulldown nears completion, the vacuum holes are once again sealed. In this manner, film tension during the major part of pulldown is decreased, making for less wear and tear on the film, while providing ample friction just prior to the completion of pulldown. Thus the "valve" for modulating the degree of vacuum is the film itself.

By the use of this system, it is possible to obtain ample gate friction and accurate film location. In addition, because the emulsion surface of the film does not come in sliding contact with the aperture plate, but instead clears it at all times by several thousandths of an inch, no scuffing of the film emulsion is encountered. As a result, long uninterrupted runs may be made, and only occasional cleaning of the film gate is necessary. By adjusting the steady-state degree of vacuum on the system, optimum conditions can be obtained for various film characteristics during operation. Most films require in the order of 20 to 22 in. of vacuum, although some need as little as 16 in. while others require as much as 27 or 28 in.

Sound Recording and Stabilization

Variable density sound is recorded by a galvanometer-type light modulator, manufactured by J. A. Maurer, Inc. It is expected that a new model modulator, interchangeable with the present one, will soon be available, which will permit

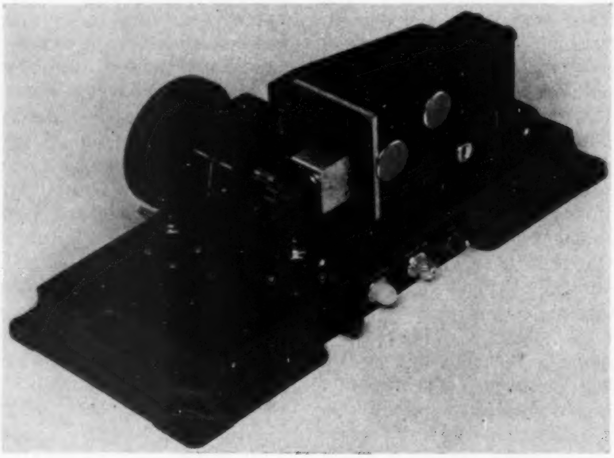

Fig. 5. Camera base with main housing removed, showing shock-mounted sound recording and stabilization equipment. The small hose connector for supplying vacuum to the film gate is visible just below the flywheel rim.

either variable area or variable density recording to be used, with only a simple adjustment required for change-over from one to the other.

Following the lower loop out of the film gate, the first component of the sound stabilization system is the film-driven viscous drag sprocket. From this, the film travels around the scanning drum which is rigidly coupled to the flywheel. A spring-loaded roller arm, following the scanning drum, combines with the drag sprocket in maintaining uniform tension on the film. This tension is approximately 5 to 6 oz. With this arrangement, no pressure roller is required on the scanning drum. In flutter tests, using this camera as a film phonograph with 3-kc standard flutter test film, flutter measures a maximum of 0.14% rms.

With the exception of the viscous drag sprocket, the entire sound recording and stabilization mechanism is assembled on a separate shock-mounted platform. Figure 5 is a picture of the camera base with the shock-mounted platform assembly in place, the main camera housing having been removed. All components are accurately and rigidly located on a casting but isolated from mechanical noise and vibration. The mechanism is jig-located on the camera base at assembly, giving correct positioning of components for alignment with the balance of the camera mechanism when the main housing is assembled with the base.

Additional Mechanical Features

The only power-driven sprocket in the camera is the combination feed and take-up sprocket which serves to feed film out of the magazine into the film gate via a compliant loop, and also to pull the film from the sound stabilizer and feed it back into the magazine (or out the rear port in case the camera is used with continuous processing equipment). Following the take-up side of the sprocket is a spring-loaded roller arm which actuates a microswitch. Should the film break, or not be properly taken up in the magazine for any reason, or should the camera run out of film, this device automatically stops the camera and turns on the film-break warning light.

With camera lens and electronic focus properly adjusted, no difficulty is encountered in resolving the line structure of a correctly interlaced picture. Furthermore, once the camera lens is correctly focused, it operates as a fixed-focus device.

Since sound and picture are recorded simultaneously at standard spacing of 26 frames, it is possible to make direct positive film, and, with the use of continuous rapid processing equipment, project the picture on a screen within 60 sec of its transmission, for the intermediate film method of theater projection television.

Although most of the work with this camera at General Precision Laboratory has been concerned with the handling of direct positives, the camera is equally capable of producing negatives, from which the necessary prints for distribution to network stations can be obtained.

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Practical Solution to the Screen Light Distribution Problem

By Charles R. Underhill, Jr.

A screen is described having a gradational perforation pattern in each of the side areas between the central portion and the extreme sides of the screen. The central portion of the screen is uniformly perforated and the extreme side areas are of unperforated screen material. This perforation design tends to compensate for the uneven light intensity from modern carbon-arc lamps, resulting in a practically even light reflection from the surface of the screen. This paper describes a screen which has been designed to have a higher reflectance in the side portions of its surface than in the center, and reasons are presented why this screen is a practical solution to the uneven light distribution problem.

It is a well-known fact that the side-to-center distribution of light on the common uniformly perforated, or unperforated, sound motion picture screen, when illuminated by the modern carbon-arc lamp, is limited to about 80%[1] under the most favorable conditions of projection equipment adjustments. In actual practice the brightness in the side portions as compared with the brightness in the center of the screen is often much less.

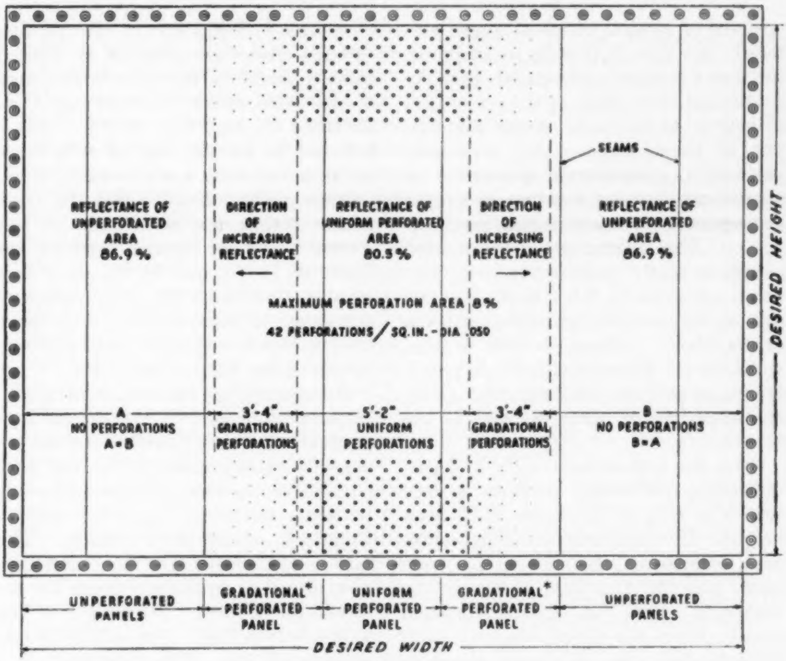
In a specific instance,[2] measurements on a screen 25 ft wide showed a brightness of 9.6 ft-L at the center of the screen, 9.2 ft-L at a point 4 ft from the center, 8.1 ft-L at a point 8 ft from the center, and 6.2 ft-L at a point 12 ft from the center. The brightness in the side portions as compared with the brightness in the center was 64.5%. This is believed to represent about the average of the ratios which exist in motion picture theaters today.

The various causes of uneven distribution of light on the screen and other light source problems are generally known and have been published in the Journal and elsewhere.[3–9] They become manifest as observable results seen on a screen surface, beyond which the screen is not otherwise involved.

The screen which appreciably compensates for the uneven illumination from the light projected upon it is known as the Snowhite Evenlite* perforated sound motion picture screen. Its design is based on a patented perforating technique which compensates for and, at least partially, counteracts the difference between the illumination

Presented on May 2, 1951, at the Society's Convention in New York, N.Y., by Charles R. Underhill, Jr., Engineering Products Dept., RCA Victor Division, Camden, N.J.

* Manufactured for and distributed by RCA.



The RCA Snowhite Evenlite Perforated Motion Picture Screen, Patent No. 2,133,097.

at the center of the screen and the side portions. Maximum perforation of 8% of total area at the center of the screen is employed where the illumination is brightest, and where the speakers behind the screen are commonly located. This portion of the screen's total area is equivalent to the common uniformly perforated screen, and has 42 perforations per square inch, each perforation being 0.050 in. in diameter. Screens made entirely of this uniform perforated material have consistently been shown by test to have less high-frequency attenuation than the losses permissible for an efficient sound screen according to SMPTE recommendations. As a matter of fact, this uniform perforation pattern is commonly used by several screen manufacturers.

However, on the side portions of the Snowhite Evenlite screen where the illumination is lowest there are no perforations. Between the center portion and each side portion of the screen is a gradational perforation area in which the perforations per square inch in a transverse direction decrease in number, as well as in diameter, until they are eliminated entirely. Thus there is a gradual transition from center to side portions from a perforated to an unperforated surface, and the change is made sufficiently gradual to be entirely imperceptible to the eye in the reflected light. At the same time, because the light reflection is reduced at the center of the screen where the illumination is highest, the brightness appears even over all portions of the screen surface.

The Snowhite Evenlite screen is constructed of vertical panels of screen material. A screen 25 ft wide, for instance, requires a total of seven panels to make up the full 25-ft width of the screen, all, of course, of the same screen material but of three types, either uniformly perforated, gradationally perforated or unperforated, sewn together in proper arrangement to meet design specifications. The gradationally perforated panels actually include uniform perforations along a 6-in. width on one side of the panel for matching with the center panel. There is also a 4-in. width on the opposite side of the panel, having no perforations for matching with the unperforated outer portions of the screen.

Thus the area of each of the two gradationally perforated portions in any screen is only 40 in. times the screen height. The uniformly perforated center area consists of the one 50 in. wide panel plus the two 6-in. widths in the matching areas of the gradational panels, times the screen height. Each unperforated area is always equal to one-half the screen width less 71 in., all times the screen height. These unperforated portions comprise equal panels of required widths to complete the full screen dimensions.

As the width of the combined uniform and gradational areas is always 142 in., the larger the screen dimensions, the greater will be the unperforated area.

The particular screen referred to, having a width of 25 ft, actually has an unperforated area 52.7% of the total area, and the uniformly perforated area is only 20.7% of the total area. The gradational area is 26.6%. For a picture size of 29 ft 9 in. by 41 ft, the unperforated area would be 71% of the total area.

Electrical Testing Laboratories have reported the reflectance of the uniformly perforated material used for the center panel of the Snowhite Evenlite screen to be 80.5%. Since the perforation area is 8%, a loss in light passing through these perforations is limited to 8%; therefore, the unperforated area of the same screen material has a reflectance 8% higher, or 86.9%. This is believed to be the highest reflectance yet obtained from a white matte sound motion picture screen. But the main point is that the reflectance of this screen varies by design between the limits of 80.5% and 86.9% in such a manner that, were the illumination of this screen uniform over the entire area, the brightness in the side portions would be 8% higher than at the center.

No attempt has been made for gradational perforations in this screen in a vertical direction, partly because of manufacturing considerations, but principally because such a refinement would be negligible in the apparent uniform brightness of the picture image. This fact is illustrated by the brightness measurements previously given for the screen 25 ft wide. The height of this screen is 18 ft 3 in. One half the height is 9 ft 1½ in. The brightness at a point 8 ft from the center was 8.1 ft-L as compared to a brightness of 9.6 ft-L at the center. It is evident from this data that the distribution of light intensity at a point approximately one foot from the top or bottom edge of the picture area was actually 84.2% of the intensity at the center, whereas at the sides of the screen the distribution was only 64.5%.

There is another factor which minimizes the effect of the ratio of top or bottom edge-to-center light. In the ordinary installation the projection when viewed in elevation is at an angle to the entire screen, and the viewing angle from an optimum seating area is less at the bottom of the screen than at the top. Therefore the difference in angularity and the consequent difference in illumination between the top and bottom of the screen is less noticeable than from the center to side por-

tions. The problem, of course, is to obtain as good a corner-to-center light ratio as possible. The Evenlite screen, having no perforations in the corners or sides, and a maximum permissible perforation area in the center, effectively accomplishes a practical solution to the problem.

The Snowhite Evenlite screen, installed in any theater, serves as a practical illustration of the fact that screens having properly designed perforation patterns and used under recommended viewing conditions have no detrimental effect whatsoever on the quality of the reflected picture. Here on a single screen surface a direct comparison can readily be made of the definition of the picture image reflected from the perforated and unperforated areas of the screen.

Though this paper is intended primarily to offer a practical solution to the screen illumination problem, the results of other tests made by Electrical Testing Laboratories are of interest when compared with ASA specifications (American War Standards Z52.45–1945 and Z52.46–1945), verifying that no sacrifices in desirable characteristics have been necessary or have been made in the development of this screen. The whiteness ratio is 92½%. Brightness at 1.5° angle of observation of the uniform perforated material is 87.5%, with a gradual dropping off to only 78% at 60° angle of observation. These tests, together with the exceptionally high reflectance and sound transmission characteristics previously referred to, combine in one screen all of the desirable qualities of both a uniformly perforated and an unperforated sound screen. What is most important, however, is that the Snowhite Evenlite screen, in appreciably compensating for uneven illumination, does a better job as a sound motion picture screen than is possible with other types of screens.

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Three New Standards

THREE RECENTLY APPROVED American Standards appear on the following pages:

1. Cutting and Perforating Dimensions for 32-Mm on 35-Mm Motion Picture Negative Raw Stock, PH22.73-1951
2. Zero Point for Focusing Scales on 16-Mm and 8-Mm Motion Picture Cameras, PH22.74-1951 (Revision of American War Standard Z52.51-1946)
3. Mounting Threads and Flange Focal Distances for Lenses on 16-Mm and 8-Mm Motion Picture Cameras, PH22.76-1951 (Revision of American War Standard Z52.50-1946)

The first standard was developed by the Film Dimensions Committee and first published as a proposal in February 1949.

The reason for the existence of this type of film (35-mm film with 32-mm perforations) is that it can be processed on 35-mm sprocketless developing machines with consequent saving in equipment. This film is commonly used for sound recording and reduction negatives. The negative thus made is printed in the usual fashion. In general, this 32-mm on 35-mm film is not used for release purposes. However, the fact that people other than manufacturers can perforate 35-mm film in this way has led to some concern. If 35-mm nitrate film were to be perforated with 32-mm perforations, it might later be slit to 16-mm size and be used in projection equipment. The standard, therefore, includes the proviso: "This film should not be made on nitrate base because if this material were slit to 16-mm it might be used on a projector with consequent danger of fire."

No proviso of this sort has been indicated in other standards because it is an unwritten law in film-manufacturing companies that no nitrate-base film should ever be slit to 8-, 16-, or 32-mm widths. The manufacturers do, however, slit both nitrate and acetate film to 35-mm dimensions. Other film users sometimes buy unperforated film and perforate it as they see fit. It was thought, therefore, that special attention should be called to the danger that might result if nitrate film were perforated to any dimensions that might make it usable on 16-mm projectors.

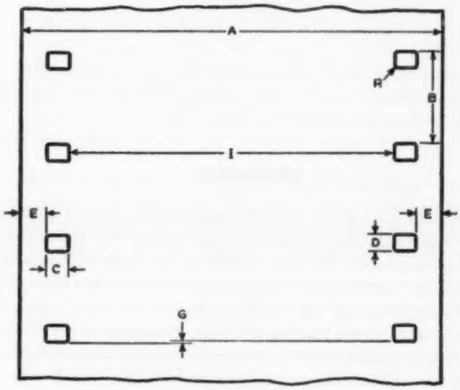
The other two standards resulted from the work of the 16-Mm and 8-Mm Committee in reviewing and revising two War Standards, Z52.50-1946 and Z52.51-1946. The revisions in both standards consisted chiefly in making them apply to 8-mm as well as 16-mm cameras.

American Standard

Cutting and Perforating Dimensions for 32-Millimeter on 35-Millimeter Motion Picture Negative Raw Stock

ASA
Reg. U. S. Pat. Off.
PH22.73-1951

*UDC 778.58



Dimensions	Inches	Millimeters
A	1.377 ± 0.001	34.98 ± 0.025
B*	0.300 ± 0.0005	7.620 ± 0.013
C	0.0720 ± 0.0004	1.83 ± 0.01
D	0.0500 ± 0.0004	1.27 ± 0.01
E	0.096 ± 0.002	2.44 ± 0.05
G	Not > 0.001	Not > 0.025
I	1.041 ± 0.002	26.44 ± 0.05
L†	30.00 ± 0.03	762.00 ± 0.76
R	0.010 ± 0.001	0.25 ± 0.03

These dimensions and tolerances apply to the material immediately after cutting and perforating.

*In any group of four consecutive perforations, the maximum difference of pitch shall not exceed 0.001 inch and should be as much smaller as possible.

†This dimension represents the length of any 100 consecutive perforation intervals.

Approved May 9, 1951, by the American Standards Association, Incorporated.
Sponsor: Society of Motion Picture and Television Engineers.

*Universal Decimal Classification

American Standard

Cutting and Perforating Dimensions for 32-Millimeter on 35-Millimeter Motion Picture Negative Raw Stock

ASA
Reg. U. S. Pat. Off.
PH22.73-1951

APPENDIX

The dimensions given in this standard represent the practice of film manufacturers in that the dimensions and tolerances are for film immediately after perforation. The punches and dies themselves are made to tolerances considerably smaller than those given, but owing to the fact that film is a plastic material, the dimensions of the slit and perforated film never agree exactly with the dimensions of the punches and dies. Shrinkage of the film, due to change in moisture content or loss of residual solvents, invariably results in a change in these dimensions during the life of the film. This change is generally uniform throughout the roll.

The uniformity of perforation is one of the most important of the variables affecting steadiness of projection.

Variations in pitch from roll to roll are of little significance compared to variations from one sprocket hole to the next. Actually, it is the maximum variation from one sprocket hole to the next within any small group that is important. This is one of the reasons for the method of specifying uniformity in dimension B.

This kind of 32-mm film is made on 35-mm stock so that it may be processed on 35-mm sprocketless negative developing machines.

This film should not be made on nitrate base, because if this material were slit to 16 mm it might be used on a projector with consequent danger of fire.

American Standard

Zero Point for Focusing Scales on 16-Millimeter and 8-Millimeter Motion Picture Cameras

ASA
Reg. U. S. Pat. Off.
PH22.74-1951
Revision of
Z52.51—1946

*UDC 778.533.25

1. Focusing scales for 16-millimeter and 8-millimeter motion picture cameras and associated lenses shall indicate object distances measured to the film plane; *i.e.*, the zero point for the focusing scale shall be in the plane of the film.

2. An index mark to indicate the film plane shall be placed on the outside of the camera. This mark shall consist of a circle crossed by a line having a length of between two and three times the diameter of the circle (see illustration below). The line shall be in the plane of the film within 0.040 inch.

Note: One way to distinguish focusing scales made in accordance with this standard is to have the words "From Film" appear after the word "Feet" or other unit designation.

Approved May 9, 1951, by the American Standards Association, Incorporated.
Sponsor: Society of Motion Picture and Television Engineers.

*Universal Decimal Classification

American Standard

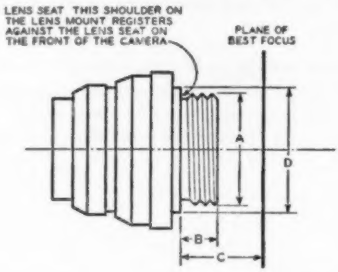
Mounting Threads and Flange Focal Distances for Lenses on 16-Millimeter and 8-Millimeter Motion Picture Cameras

ASA
Reg. U. S. Pat. Off.
PH22.76-1951
Revision of
Z52.50—1946

*UDC 778.53:771.352

1. Purpose

1.1 The purpose of this standard is to describe the two sizes of screw threads and the related flange focal distances in common use for mounting objective lenses on 8-millimeter and 16-millimeter motion picture cameras. The external thread is on the lens, and the internal thread is in the camera.



Nominal (Major) Diameter of Lens Attaching Thread	Threads Per Inch	Length from Shoulder to End of Thread	Flange Focal Distance	Diameter of Lens Seat
A Inch		B Inch	C Inch	D Inch
0.625	32	0.115	0.484	1.000
1.000	32	0.160	0.690	1.187

2. Dimension A

2.1 The American National Thread Form should be used.

Dimensions and tolerances shall conform to those established for a Class-2 fit by the National Bureau of Standards Handbook, H28, Screw Thread Standards for Federal Services (Section V, Screw Threads of Special Diameters, Pitches, and Lengths of Engagement).

3. Dimension B

3.1 The values given for this dimension in the above table are to be considered as the maximum for the lens; a little additional length, for clearance, should be provided in the camera.

Approved May 9, 1951, by the American Standards Association, Incorporated.
Sponsor: Society of Motion Picture and Television Engineers.

*Universal Decimal Classification

3.2 With some lenses a section of the mount, with a diameter smaller than the root of the thread, necessarily extends closer to the film than is indicated by the drawing. In those cases, the mechanical clearance in the camera must be determined individually.

3.3 In the past, a number of lenses with the 1-inch thread had a B dimension of 0.187 inch. This is considered to be an obsolete practice.

3.4 Past practice has not been entirely consistent so far as the B dimension of the 0.625-inch thread is concerned; some existing cameras will not accept a thread longer than 0.115 inch; some lenses have been made with a length of 0.120 or 0.125 inch.

4. Dimension C

4.1 This dimension is defined as the distance from the lens seat to the plane of the best photographic image. It should be determined photographically with panchromatic film and with the camera operating normally. Sometimes a compromise is necessary between best central definition and best over-all definition.

4.2 The tolerance acceptable for dimension C is dependent on the depth of focus and on a decision as to what portion of the depth can be used for the focus tolerance. In some cases, the tolerance is very small. For example, with a 25-millimeter f/1.4 lens and a 0.001-inch circle of confusion, the depth of focus is 0.0014 inch; only part of this is available for the sum of the lens and camera focusing tolerances.

5. Dimension D

5.1 The values given in the table are to be considered as the maximum diameter of the seat on the lens; the seat on the camera should provide clearance for these diameters.

5.2 If any part of the lens mount has a larger diameter, it should be checked for mechanical interference with the camera on which it is to be used. Some lenses with the 1-inch thread have been made with a flange diameter of 1.500 inches.

Note: This standard does not apply to continuous-type motion picture cameras because of the type of optical system employed in these cameras.

70th Semiannual Convention

Plans for the fall convention are progressing: Bill Kunzmann has been in Hollywood with Peter Mole, John Frayne, and the other Pacific Coast folks who are making the initial plans and will see the Convention through to a happy conclusion at the Hollywood-Roosevelt, October 15–19. We can rely on them for a well organized program, carefully developed in advance and executed with customary dispatch.

PAPERS

Ed Seeley, Chairman of the Papers Committee, and Fred Albin, Hollywood Program Chairman, have announced the author's form and manuscript deadline which must guide prospective authors in preparing their contributions for the 70th Convention program. By August 1 the buff copy of the author's form is to reach Fred Albin and must include a 50-word abstract that will become part of both the tentative and the final programs.

By August 31 the white copy of the author's form must reach Vic Allen, the Society's editor, at 40 West 40th Street, New York 18, accompanied by two copies of the manuscript and one complete set of illustrations. Fred Albin will begin work promptly on the Convention programs and Vic Allen will prepare manuscripts and illustrations for early consideration by the Board of Editors.

Prospective authors should secure their author's forms and a few suggestions entitled "Hints for SMPTE Authors," prepared by the editors, and any other essential information concerning their part in the forthcoming Convention by writing directly to any of the following:

PAPERS COMMITTEE

Chairman, Edward S. Seeley, Altec Service, 161 Sixth Ave., New York 13
70th Convention Program Chairman: Fred G. Albin, Station KECA-TV, American Broadcasting Company Television Center, Hollywood 27, Calif.
Vice-Chairmen
For New York: W. H. Rivers, Eastman Kodak Co., 342 Madison Ave., New York 17
For Washington: J. E. Aiken, 116 N. Galveston St., Arlington, Va.
For Chicago: R. T. Van Niman, 4441 Indianola Ave., Indianapolis, Ind.
For Los Angeles: F. G. Albin (see above)
For Canada: G. G. Graham, National Film Board of Canada, John St., Ottawa, Canada
For High-Speed Photography: J. H. Waddell, Wollensak Optical Co., 850 Hudson Ave., Rochester, N.Y.
For High-Speed Photography for Los Angeles: Roy L. Wolford, 3434 W. 110th. St., Inglewood 2, Calif.

Committee Members
A. C. Blaney, RCA Victor Div., 1560 N. Vine St., Hollywood 28, Calif.
Richard Blount, General Electric Co., Nela Park, Cleveland, Ohio.
R. P. Burns, Balaban & Katz, Great States Theaters, 177 N. State St., Chicago 1, Ill.
Philip Caldwell, American Broadcasting Co., 6285 Sunset Blvd., Hollywood, Calif.
F. O. Calvin, The Calvin Co., 1105 E. Fifteenth St., Kansas City 6, Mo.
Howard Chinn, Columbia Broadcasting System, 485 Madison Ave., New York 22.
J. P. Corcoran, Twentieth Century-Fox Film Corp., 10201 W. Pico Blvd., Beverly Hills, Calif.
G. R. Crane, Westrex Corp., 6601 Romaine St., Hollywood 38, Calif.
E. W. D'Arcy, De Vry Corp., 1111 W. Armitage Ave., Chicago 14, Ill.
Farciot Edouart, Paramount Pictures Corp., 5451 Marathon St., Hollywood 38, Calif.
F. L. Eich, Paramount Film Laboratory, 1546 Argyle Ave., Hollywood 28, Calif.
Dudley Goodale, National Broadcasting Co., 30 Rockefeller Plaza, New York 20
Charles Handley, National Carbon Div., 841 E. Fourth Pl., Los Angeles 13, Calif.

R. N. Harmon, Westinghouse Radio Stations, Inc., 1625 K St., N.W., Washington, D.C.

Scott Helt, Allen B. Du Mont Labs., Inc., 2 Main Ave., Passaic, N.J.

C. E. Heppberger, National Carbon Div., 230 N. Michigan Ave., Chicago 1, Ill.

J. K. Hilliard, Altex Lansing Corp., 1161 N. Vine St., Hollywood 38, Calif.

L. Hughes, Hughes Sound Films, 21 S. Downing St., Denver, Colo.

P. A. Jacobson, University of Washington, Seattle, Wash.

William Kelley, Motion Picture Research Council, 1421 N. Western Ave., Hollywood 27, Calif.

E. P. Kennedy, Signal Corps Labs, Fort Monmouth, N.J.

George Lewin, Signal Corps Photographic Center, 35-11 35 St., Long Island City 1, N.Y.

E. C. Manderfeld, Mitchell Camera Corp., 666 W. Harvard St., Glendale 4, Calif.

Glenn Matthews, Research Laboratory, Eastman Kodak Co., Rochester 10, N.Y.

Pierre Mertz, Bell Telephone Labs., Inc., 463 West St., New York 14

James Middlebrooks, American Broadcasting Co., 30 Rockefeller Plaza, New York 20

Harry Milholland, Allen B. Du Mont Labs, Inc., 515 Madison Ave., New York 22

W. J. Morlock, General Electric Co., Electronics Park, Syracuse, N.Y.

Herbert Pangborn, Columbia Broadcasting System, Inc., 6121 Sunset Blvd., Hollywood 28, Calif.

Edward Schmidt, Reeves Soundcraft, 10 E. 52 St., New York 22

N. L. Simmons, Eastman Kodak Co., 6706 Santa Monica Blvd., Hollywood 38, Calif.

S. P. Solow, Consolidated Film Industries, Inc., 959 Seward St., Hollywood 38, Calif.

J. G. Stott, Du-Art Film Laboratories, 245 W. 55 St., New York 19

W. L. Tesch, Radio Corporation of America, RCA Victor Div., Front and Cooper Sts., Camden, N.J.

S. R. Todd, Consulting Electrical Engineer, 4711 Woodlawn Ave., Chicago, Ill.

M. G. Townsley, Bell & Howell, 7100 McCormick Rd., Chicago 45, Ill.

Engineering Activities

Standardization Facilitated by RCA

The Engineering Committee on Optics under the chairmanship of R. Kingslake has been preparing in recent months a Proposed American Standard for the Aperture Calibration of Motion Picture Lenses. The purpose of this standard is to define a suitable method for the measurement and marking of the transmittance of photographic objectives, so that the user may have a more reliable guide to the exposure resulting from a given lens opening than can be derived from the present-day *f*/numbers.

One very good method for doing this is described in U.S. Patent 2,419,421, "Method of Calibrating Lenses with Respect to Effective Optical Speed," granted to L. T. Sachtleben and assigned to the Radio Corporation of America. The Optics Committee valued this method sufficiently to include it in the present Proposed Standard, even though the patent might have proved a bar to its universal availability, and so to its ultimate acceptance as an American Standard.

Recognizing this situation, the Radio Corporation of America has generously agreed to grant a paid-up license under the patent mentioned for the sum of only $10.00. This nominal fee makes the calibration method easily available to anyone interested in using the present proposal, and also facilitates the retention of the method in the ultimate American Standard. R. H. Heacock, RCA Product Manager, Theatre Equipment, outlines the following procedure for securing a license under the Sachtleben patent:

"If you will kindly arrange to let me know the full name of the companies interested in a license of this kind together with the name of the State in which the corporation, partnership or proprietorship, as the case may be, is registered and the

address at which the company is located, we would be glad to prepare and forward to them an executed copy of the Agreement.

"We hope that the Industry will be able to make use of this patent to good advantage."

The Engineering Committees of SMPTE are unique in providing opportunity for competitors in commercial life to meet, discuss and resolve technical problems for the common good. The present contribution of the Radio Corporation of America to this cooperative effort is deeply appreciated.—F.T.B.

Inter-Society Color Council

The ISCC color names work is actively in progress and is headed in a somewhat different direction from the work in the two publications recently reviewed (see p. 594 of the May JOURNAL), for instead of keying names to specific samples the ISCC plan is to specify *limits* for color designations. The 1939 report by Judd and Kelley, *Method of Designating Colors*, NBS RP 1239, is out of print; a revision is near completion, and should be published within the next year. It will contain, not only specifications for limits for the color name blocks defined in the report, but in an Appendix the color names used in practically all standard works on color names will be related to the ISCC-NBS names. The revision should be more useful than the original report, and the Government Printing Office found that to be one of its best sellers!—DOROTHY NICKERSON, Secretary, Inter-Society Color Council, Box 155, Benjamin Franklin Station, Washington 4, D.C.

BOOK REVIEW

Film and Its Techniques

By Raymond Spottiswoode. Published (1951) by University of California Press, Berkeley, Calif. 532 pp. Illustrated by Jean-Paul Ladouceur. 6 × 9 in. Price $7.50.

Here is a book for which there has long been a need. Of books on "the cinema," there is a wide selection from all parts of the world, some written by film makers, most by critics and admirers. The theory and aesthetics of this medium have been well discussed. Raymond Spottiswoode himself, in his earlier book, *A Grammar of the Film*, published during the late thirties, probably carried the analysis of film art into higher and thinner realms than anyone short of Eisenstein.

At the other end of the scale, the literature on the technical and engineering aspects of this complex field has followed many special avenues, none of which is entirely comprehensible to the average film maker or the student of film production. There have been hardly any books on the actual practice of film production. Although the student could read widely about cinema, until now he has been unable to buy a book which would tell him how to make a film.

Written by a film producer (documentary) and directed at the student or the worker in film production, this book goes surprisingly far into a basic technical understanding of such areas as the mechanics, chemistry, and optics of film making, without leaving the non-technical reader behind. It will be immediately adopted as a standard text in film production courses everywhere. The book is excellently illustrated with imaginatively conceived diagrams which in themselves contribute greatly to the reader's understanding of complicated processes.

But its value does not stop there. There are few film makers or technicians whose knowledge of the medium is so comprehensive that they would have little to learn from *Film and Its Techniques*. It is a very smoothly written book, and most readers will probably read it right through. The book contains an excellent 90-page glossary and a book list of almost a hundred volumes on various aspects of film, with a paragraph of evaluation for each. It is a long-awaited and eagerly welcomed book.—RUDY BRETZ, Croton-on-Hudson, N. Y.

David Sarnoff Gold Medal Award

Technical contributions to television can now be acknowledged by presentation of this annual award made available this year for the first time by the Radio Corporation of America. Candidates for the first award are now being considered by a five-member committee: Raymond L. Garman, General Precision Laboratory, Inc.; Thomas T. Goldsmith, Jr., Allen B. DuMont Laboratories; O. B. Hanson, National Broadcasting Company; William B. Lodge, Columbia Broadcasting System; and Pierre Mertz (chairman), Bell Telephone Laboratories.

Recommendations will be reviewed at the July 19, 1951, meeting of the Society's Board of Governors and if agreement is reached on a suggested recipient the award will probably be presented at the Wednesday night (October 17, 1951) banquet during the Society's 70th Convention in Hollywood. The following official statement has been extracted from the Society's records.

Name of Award **The David Sarnoff Gold Medal**

To be presented annually to that individual selected by the Society of Motion Picture and Television Engineers who has done outstanding work in some technical phase of the broad field of television *engineering,* whether in research, development, design, manufacture, operation, or in any similar phase of theater television.

Purpose The purpose of this Award is to recognize recent technical contributions to the art of television, and to encourage the development of new techniques, new methods, and new equipment which hold promise for the continued improvement of television.

Eligibility The Award *may* be presented to any qualified person whether or not currently a member of the Society of Motion Picture and Television Engineers.

Award The Award shall consist of a gold medal of suitable design, and may be presented at the Annual Meeting of the Society, together with a bronze replica and a citation, stating the recipient's qualifications.

Qualifications and Procedure for Selecting the Recipient The President of the Society shall, each year, appoint a committee, consisting of a Chairman and four members, each of whom shall be qualified to judge the importance or value of current work in some technical phase of the broad field of television *engineering,* whether in research, development, design, manufacture, operation, or in any similar phase of theater television. The Chairman and members of the committee must be Fellows or Honorary Members or have received previously some formal Society Award.

In selecting a roster of candidates for the Award from whom the recipient shall be chosen, preference shall be given to work having reached completion within the preceding five years. Contributions which have led to greater fidelity in reproduction of an original scene, or to simplification of the processes involved, shall be important considerations. The Award shall be made to a particular individual, and if other persons were concerned with the developments which constitute qualification, the individual shall be considered favorably only if he contributed the basic idea and was intimately concerned with its subsequent development.

A Citation (suitable for display) shall be prepared, outlining in reasonable detail the work of the recipient so that it may be understood by anyone skilled in the art.

If in any year the committee does not consider any recent developments to be adequate qualifications for the Award, it shall recommend that no Award be made.

Recommendations of the committee and a report of its deliberations shall be presented to the Board of Governors three months in advance of the time for presentation.

New Members

The following members have been added to the Society's rolls since those published last month. The designations of grades are the same as those used in the 1950 MEMBERSHIP DIRECTORY.

Honorary (H) Fellow (F) Active (M) Associate (A) Student (S)

Baird, Kenneth M., Physicist, National Research Laboratories, Ottawa, Ont., Canada. **(A)**

Bauer, Eldon E., Director, Quality Control, Eastman Kodak Co. **Mail:** 1712 Prairie Ave., Chicago, Ill. **(M)**

Borden, Richard, 16-Mm Film Producer. **Mail:** 1031 Canton Ave., Milton, Mass. **(A)**

Burr, R. Page, Engineer, Research Div., Hazeltine Corp., 58–25 Little Neck Pkwy., Little Neck, L.I., N.Y. **(A)**

Chase, Robert H., Film Production Supervisor, N. W. Ayer & Son, Inc., 30 Rockefeller Plaza, New York 20, N.Y. **(A)**

Christie, Dana B., Cine Sales Representative, E. I. du Pont de Nemours & Co. **Mail:** 3289 N. California Ave., Chicago 18. **(M)**

Cooke, James F., Commercial Motion Picture Producer, Highways Bureau, Portland Cement Assn. **Mail:** 633 Beaver Rd., Glenview, Ill. **(A)**

Cooke, Norman C., University of Hollywood. **Mail:** 1023 N. Edgemont St., Hollywood 29, Calif. **(S)**

Coudereau, Pierre, Architect–Decorator. **Mail:** 27 Rue Auber, Algiers, Algeria, French North Africa. **(M)**

Cromwell, Victor H., Television Technician, Columbia Broadcasting Co. **Mail:** R.D. #1, Darien, Conn. **(A)**

De Lorenzi, Otto, Director of Education & Fuels Consultant, Combustion Engineering – Superheater, Inc., 200 Madison Ave., New York 16, N. Y. **(M)**

Dun, Manne, P.O. Box 4192, Johannesburg, South Africa. **(A)**

Fallon, John, Surgeon, Fallon Clinic. **Mail:** 10 Institute Road, Worcester 2, Mass. **(A)**

Finlay, W. G., Laboratory Technician, African Film Productions, Ltd. **Mail:** P.O. Box 2787, Johannesburg, Transvaal, South Africa. **(A)**

Gellert, Hal, TV Technician, Columbia Broadcasting System, Inc. **Mail:** 585 West End Ave., New York, N. Y. **(A)**

Hall, Edward B., Manager, Informational Films Div., Eastman Kodak Co., 343 State St., Rochester 10, N. Y. **(A)**

Haynie, Donald Bruce, Chemical Engineer, Ansco Div. **Mail:** Box 11464 Briggs Station, Los Angeles 48, Calif. **(A)**

Hilliard, Allen F., Boston University. **Mail:** 210 Bay State Rd., Boston, Mass. **(S)**

Hungerford, E. Arthur, Jr., Television Engineer, General Precision Laboratory, Inc. **Mail:** Campfire Rd., Chappaqua, N.Y. **(M)**

Ilowite, Ralph, Radio-Television Broadcasting Engineer, American Broadcasting Co. **Mail:** 479 Dorchester Rd., Ridgewood, N. J. **(A)**

Kalkowsky, Henry, Hollywood Sound Inst. **Mail:** 839 N. Edgemont St., Los Angeles 27, Calif. **(S)**

Kramer, Vernon W., Assistant Director of Sound, Universal-International Pictures Co. **Mail:** 15441 Sutton St., Sherman Oaks, Calif. **(M)**

Lachman, Edward, President, Lorraine Carbons, Inc. **Mail:** Humphrey Rd., Morristown, N. J. **(M)**

Leonard, Robert A., Cinematographer, Medical College of Alabama, Birmingham, Ala. **(M)**

Mac Dermott, A. P., Co-owner, Industrial Motion Pictures, 1706 E. 38th St., Cleveland, Ohio. **(A)**

Morris, Dwight, Film Producer, Mt. Sequoyah, Fayetteville, Ark. **(M)**

Reingold, Edward, New York University. **Mail:** 485 E. 21 St., Brooklyn 26. **(S)**

Schrier, Eugene, New York University. **Mail:** 5015 Clarendon Rd., Brooklyn 3, N.Y. **(S)**

Soame, Reginald, Director, School of Photographic Arts, Dept. of Education, Province of Ontario. **Mail:** 1720 Avenue Rd., Toronto, Ont., Canada. **(M)**

Srinivasan, C., c/o B. R. Chakravarthi, Judge, Pudukkottai, Madras Province, India. **(M)**

Stone, Leroy S., Electrical Engineer, American Broadcasting Co. **Mail:** 38 E. Third St., New York, N.Y. **(A)**

Stratton, Floyd Grant, High-Speed Specialist, Bell Aircraft Corp. **Mail:** Whitehaven Rd., Grand Island, N.Y. **(A)**

Trouant, Virgil Elmer, Manager, Broadcast Engineering Section, RCA Victor Div. **Mail:** 250 Wayne Ave., Haddonfield, N.J. **(A)**

Ward, Edwin J., Training Assistant, Shell Oil Co. **Mail:** 95 East Poplar St., Zionsville, Ind. **(A)**

Webb, Richard C., Research Engineer, RCA Laboratories. **Mail:** Random Rd., R.D. #1, Princeton, N.J. **(M)**

Whittaker, John R., Colorfilm, Inc., 41-17 Crescent St., Long Island City 1, N.Y. **(M)**

Wolford, Roy L., Supervisor, Engineering Photography, Northrop Aircraft, Inc.

Mail: 3434 W. 110 St., Inglewood 2, Calif. **(A)**

Woods, L. C. (Bud), Film Producer, Bud Woods Productions, Inc. **Mail:** 1601 S. Boston Ave., Tulsa, Okla. **(M)**

Zeigler, Carl F., Commercial Films Producer, Educational Films Bureau, Portland Cement Assn. **Mail:** 143 Burton Pl., Chicago 10, Ill. **(A)**

CHANGES IN GRADE

Percy, Charles H., President, Bell & Howell Co., 7100 McCormick Rd., Chicago 45, Ill. **(A)** to **(M)**

Rafferty, Howard T., Sensitometrist, Cinecolor Corp. **Mail:** 1316 Spazier Ave., Glendale 1, Calif. **(A)** to **(M)**

Tompkins, Rutledge B., President, International Projector Corp., 55 La France Ave., Bloomfield, N.J. **(A)** to **(M)**

Trevor, Don-Marc, Motion Picture Consultant, DuMont Television Network. **Mail:** 825 W. 180 St., New York 33, N.Y. **(A)** to **(M)**

Current Literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer

vol. 32, no. 1, Jan. 1951

Cinerama—Super Movies of the Future (p. 12)

A New Revolving Camera Mount (p. 14) F. Foster

New Technique for "Sync" Sound on Quarter-Inch Magnetic Tape (p. 16) W. D. Fling

vol. 32, no. 2, Feb. 1951

Will There Always be a Need for Carbon Arcs? (p. 50) P. Mole

A Bantam-Weight Camera for Underwater Photography (p. 52) H. S. Moncrief

New Technique for "Sync" Sound on Quarter-Inch Magnetic Tape (p. 53) W. D. Fling

The Practical Use of Latensification (p. 54) P. Tannura

Light Source for TV Newsreel Cameramen (p. 58) B. Berg

Meet the New 70-DL (p. 62) F. Foster

British Kinematography

vol. 17, no. 4, Oct. 1951

Motion Picture Camera Development (p. 105) G. Hill

Measurement of Brightness and Illumination of the Kinema Screen (p. 118) F. S. Hawkins and H. W. W. Losty

Electronics

vol. 24, no. 2, Feb. 1951

Telemetering System for Radioactive Snow Gage (p. 88) J. A. Doremus

International Projectionist

vol. 26, no. 1, Jan. 1951

Carbon Arcs vs. Inkies for Non-Theatrical Projection (p. 13) H. H. Strong

This Mysterious Aerial Image (p. 15) R. A. Mitchell

New Technicolor Lighting System Tested by Top-Flight Cinematographers (p. 20) L. Allen

vol. 26, no. 3, Mar. 1951

New Eastman Identification System for Safety Film (p. 12)

Variable Shutters in 16-Mm Filming (p. 23) J. Forbes

Photographic Journal

vol. 91B, sec. B, no. 1, January–February 1951

Some Factors in Pictorial Reproduction Processes With Special Reference to Television (p. 2) R. G. Hopkinson, R. B. Mackenzie and R. D. Nixon

Proceedings of the I.R.E.

vol. 39, no. 3, Mar. 1951

Television Image Reproduction by Use of Velocity-Modulation Principles (p. 265) M. A. Hannell and M. D. Prince

Use of Image Converter Tube for High-Speed Shutter Action (p. 268) A. W. Hogan

Tele-Tech

vol. 10, no. 4, Apr. 1951

JTAC Color Television System Comparison Table (p. 33)

Color-TV Progress (p. 43)

Tele-Vision Engineering

vol. 2, no. 1, Jan. 1951

Perspective Distortion in TV Pictures (p. 12) E. C. Lloyd

vol. 2, no. 2, Feb. 1951

Perspective Distortion in TV Pictures (p. 18) E. C. Lloyd

The Five-Year Index

Five years of the Society's Journal amount to sixty issues in ten semiannual volumes. From January 1946 through December 1950 the contemporary history of both industries served by our Society has been set down. To make this information easy to find takes a lot of indexing plus a lot of packing and poking to package it as neatly as we tried to in what went to you as Part II of your May Journal.

Headquarters put a great deal into the Index—not only to give it some unique features but also to make it as readily useful as possible. We hope you have had a chance to review it and will tell us what you think of it—and also we hope that after you've used it a while you will send in your suggestions and criticisms so they can be hung on the spindle to be handy when 1955 rolls around and we begin packing and poking again.

Journals Out of Stock: The Society's stock of Journal issues for March, Part II, July, August, September, 1949, and February, 1950, has been exhausted as a result of an unexpected increase in demand and the Society's Headquarters is anxious to purchase a stock of each. Members or libraries having extra copies available are invited to send them in. The going price is 75c.

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April Journal.

New Products

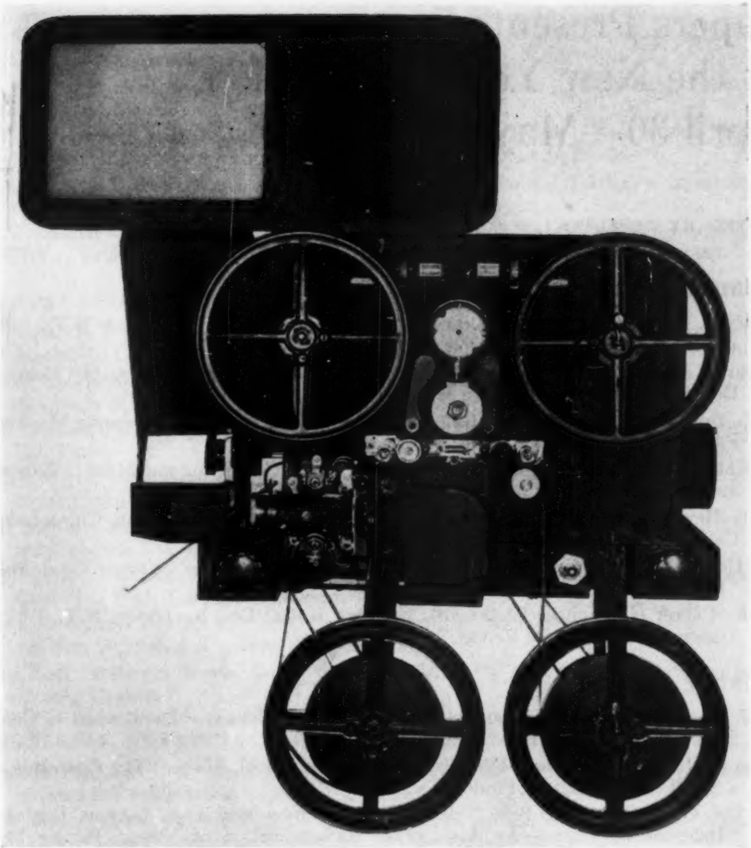
Further information about these items can be obtained from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of news items does not constitute an endorsement.

The Metro-Lite Vaudeville is a new spotlight put on the market this year by Genarco, Inc., 36–56 34th St., Long Island City 6, N.Y. It is a high-intensity carbon-arc spotlight which operates at between 60 and 85 amp, 40 to 60 volts d-c. It is used in large theaters, wherever the throw is 75 to 250 ft, with the same rectifier or generator as the projection lamp in the booth. A modern four-lenses optical system combines with an automatic iris to provide, according to the manufacturer, a sharply defined outline with no blurring. The positive 9-mm × 20-in. high-intensity carbon is continuously rotated, and it, with the negative $\frac{5}{16}$-in. copper-coated high-intensity carbon, is automatically fed by a silent motor. A single wheel automatically focuses the spot, opens the inside iris and controls the size of the spot.

Genarco also manufactures the Metro-Lite, a high-intensity carbon-arc spotlight which operates at 125 amp, 55 to 60 volts d-c. It is used in arenas, very large cinemas, auditoriums or theaters, wherever the throw is 100 to 400 ft.

The Munsell Chart-Photometer is described in a new brochure from Munsell Color Co., Inc., 10 E. Franklin St., Baltimore 2, Md. The chart is an assembly of 11 value-reflectance scales with instructions, and it sells for **$15.00.**

The system is designed for three illuminants: incandescent light, average daylight and light from blue sky. One of the 11 charts is a special scale of 19 neutrals and the other charts are each for one of the 10 major hues. The brochure continues with an example and explanation of computing reflectance characteristics for the 189 color standards of the Chart-Photometer.



This 16-Mm Double-System Editing Machine for motion picture film and sound track is now being produced by M. W. Palmer, 468 Riverside Drive, New York 27. This editor was designed especially to meet the needs of the professional 16-mm industry.

There are separate film channels—for sound and for picture. Each channel is separately controlled. Either film can be operated independently of the other, or both channels can be interlocked, to make both films run in synchronism.

Composite film can be run by threading through both picture and sound heads, which are spaced properly, to give correct distance between picture and sound. Separate frame and footage indicators are provided, one for each film, and if desired, cutting can be done without marking the film, by notation of the foot and frame number, where the cut is to be made. The machine is furnished with magnetic pickup from 16-mm perforated magnetic film if required. A foot-pedal speed control is provided and there is a reverse switch for operation in either direction.

Papers Presented at the New York Convention, April 30—May 4

Listed by Sessions

MONDAY AFTERNOON

Henry J. Hood (Committee Chairman), Eastman Kodak Co., Rochester, N.Y., "16- and 8-Mm Motion Pictures Committee Report."

Edgar E. Berger, Du-Art Film Laboratories, Inc., New York, "The Quality Control Department of a Medium Size Motion Picture Laboratory."

F. L. Bray, Du-Art Film Laboratories, Inc., New York, "A New Processing Machine Film Spool for Use With Either 35-Mm or 16-Mm Film."

L. Katz and W. Esthimer, Raytheon Manufacturing Co., Waltham, Mass., "Experiments in High-Speed Processing Using Turbulent Fluids."

H. E. Hewston and Carlos H. Elmer, U.S. Naval Ordnance Test Station, China Lake, Calif., "A Continuous Processing Machine for Wide Film."

W. Hedden, T. Weaver and Lloyd Thompson, The Calvin Co., Kansas City, Mo., "Processing 16-Mm Kodachrome Prints."

E. K. Carver (Committee Chairman), Eastman Kodak Co., Rochester, N.Y., "Film Dimensions Committee Report."

MONDAY EVENING

R. J. Ross, National Film Board of Canada, Ottawa, Canada, "Duplication of Color Images With Narrow Band Filters."

Morton H. Read, Bay State Film Productions, Springfield, Mass., "The Operation of a Small Motion Picture Production Studio."

Lt. Col. G. R. Stevens, O.B.E., Television Film Productions, Ltd., London, England, "Independent Frame—An Attempt at Rationalization of Motion Picture Production."

Herbert Meyer, Motion Picture Research Council, Inc., Hollywood, Calif., "Nonphotographic Aspects of Motion Picture Production."

J. S. Leffen, LCDR., U.S.N., U.S. Naval Photographic Center, Anacostia, D.C., "Experimental Utilization of Television Equipment for Navy Training Film Production."

TUESDAY MORNING

R. L. Garman (Committee Chairman), General Precision Laboratory, Pleasantville, N.Y., "Films for Television Committee Report."

Howard Chinn, Columbia Broadcasting System, New York, "The Over-all Factors in Television Recording Operations."

Kendel Foster, William Esty Agency, New York, "Film Problems from the Advertising Agency Point of View."

Frank LaPore, National Broadcasting Co., New York, "The Distribution of Kinescope Films to Maintain a Television Network."

P. J. Herbst, R. O. Drew and S. W. Johnson, RCA Victor Division, Camden, N.J.' "Electrical Compensation vs. Photographic Masking in the Improvement of Contrast and Detail in Televised Film."

Fred G. Albin, American Broadcasting Co., Hollywood, Calif., "Gray Scale Control in Video Systems."

K. B. Benson and A. B. Ettlinger, Columbia Broadcasting System, New York, "Practical Use of Iconoscopes and Image Orthicons as Film Pickup Devices."

W. D. Kemp, British Broadcasting Corp., London, England, "Television Recording in Great Britain."

F. N. Gillette (Committee Chairman), General Precision Laboratory, Pleasantville, N.Y., "Joint RTMA-SMPTE Television Film Equipment Committee Report."

TUESDAY AFTERNOON

R. Bown, Bell Telephone Laboratories, Murray Hill, N.J., Speech of Welcome to Assembled Group.

M. W. Baldwin, Jr., Bell Telephone Laboratories, Murray Hill, N.J., "Subjective Sharpness of Additive Color Pictures."

A. G. Jensen, Bell Telephone Laboratories, Murray Hill, N.J., Description of Murray Hill Tour.

Pierre Mertz, Bell Telephone Laboratories, Murray Hill, N.J., "Data on Random Noise Requirements for Theater Television."

D. T. Wilber, Allen B. DuMont Laboratories, Clifton, N.J., "The Conversion of Electrical Signals into Visual Information."

E. C. Fritts, Eastman Kodak Co., Rochester, N.Y., "A 16-Mm Projector for Storage Operation With Television Cameras."

Frank N. Gillette and R. A. White, General Precision Laboratory, Pleasantville, N.Y., "A New Television Recording Camera."

John Kiel, Producers Service Corp., Burbank, Calif., "A New 35-Mm Television Recording Camera."

WEDNESDAY MORNING — Two Sessions

Kenneth Shaftan, J. A. Maurer, Inc., Long Island City, N.Y., "Progress in Photographic Instrumentation."

J. W. Beams and J. M. Watkins, University of Virginia, Charlottesville, Va., "A High Constant-Speed Rotating Mirror."

W. L. Hicks and R. L. Wright, Burroughs Adding Machine Co., Detroit, Mich., "Practical Application of High-Speed Photography in Business Machines."

R. V. Bernier, Maj., USAF, Wright-Patterson Air Force Base, Dayton, Ohio, "Three-Dimensional Motion Picture Applications."

W. W. Lozier (Committee Chairman), National Carbon Division, Fostoria, Ohio, "Report on Screen Brightness Committee Theater Survey."

H. J. Benham, RCA Victor Division, Camden, N.J., "Studies and Comparisons of Current Motion Picture Projection Systems for Indoor and Drive-In Theaters."

F. J. Kolb, Jr., and F. Urbach, Eastman Kodak Co., Rochester, N.Y., "Temperature-Sensitive Phosphors for Evaluating Air Jets Designed to Cool Motion Picture Film."

G. Gagliardi, Warner Brothers Theaters, Newark, N.J., and A. T. Williams, Weston Electrical Instrument Co., Newark, N.J., "An Instrument to Measure Total Light Output at the Lens."

Charles R. Underhill, Jr., RCA Victor Division, Camden, N.J., "The Practical Solution to the Screen Light Distribution Problem."

W. G. Hill, Ansco Division, General Aniline & Film Corp., Binghamton, N.Y., "Modified Negative Perforation Proposed as a Single Standard for 35-Mm Motion Picture Film."

R. W. Lavender, Ansco Division, General Aniline & Film Corp., Binghamton, N.Y., "Photoelectric Method for Evaluating Steadiness of Motion Picture Film Images."

WEDNESDAY AFTERNOON — Two Sessions

Alsede W. Hogan, Naval Ordnance Laboratory, Silver Spring, Md., "Use of Image Phototube as a High-Speed Camera Shutter."

S. A. Weinberg, J. S. Watson, Jr., M.D., and G. H. Ramsey, M.D., University of Rochester School of Medicine and Dentistry, Rochester, N.Y., "Cinefluorography, Mechanical Factors and Diagnostic Applications."

Eugene L. Perrine and Nelson W. Rodelius, Armour Research Foundation, Chicago, Ill., "Simultaneous High-Speed Arc Photography and Data Recording With 16-Mm Fastax Camera."

E. M. Lowry, Eastman Kodak Co., Rochester, N.Y., "The Luminance Discrimination of the Human Eye."

David L. MacAdam, Eastman Kodak Co., Rochester, N.Y., "Influence of Color of Surround on Hue and Saturation."

S. D. S. Spragg, University of Rochester, Rochester, N.Y., "Visual Performance on Perceptual Tasks at Low Photopic Brightnesses."

H. L. Logan, Holophane Co., Inc., New York, "Photometric Factors in the Design of Motion Picture Auditoriums."

Sylvester K. Guth, General Electric Co., Cleveland, Ohio, "Surround Brightness: Key Factor in Viewing Projected Pictures."

Benjamin Schlanger and William A. Hoffberg, Theater Engineering and Architecture Consultants, New York, "New Approaches Developed by Relating Film Production Techniques to Theater Exhibition."

THURSDAY MORNING

E. A. Andres, Sr., and H. P. Roganti, Wright-Patterson Air Force Base, Dayton, Ohio, "High-Speed Photography."

Karl Maier, Springfield Arsenal, Springfield, Mass., "A Slide Rule for Analyzing High-Speed Motion Picture Data."

Brian O'Brien, University of Rochester, Rochester, N.Y., "A Printer for Image Dissection Camera Negatives."

Robert Rice, University of North Carolina, Chapel Hill, N.C., "A Study of Flames."

John H. Waddell (Committee Chairman), Wollensak Optical Co., Rochester, N.Y., "High-Speed Committee Report."

THURSDAY AFTERNOON

Samuel R. Todd, Board of Examiners, City of Chicago, Chicago, Ill., "Safety Requirements in Projection Rooms and Television Studios."

Otto H. Schade, Tube Dept., RCA Victor Division, Harrison, N.J., "A New System of Measuring and Specifying Image Definition."

H. G. Kobrak, M.D., University of Chicago, Chicago, Ill., "Auditory Perspective."

E. Arthur Hungerford, Jr., General Precision Laboratory, Inc., Pleasantville, N.Y., "Techniques for Producing Electronic Movies."

Richard Blount (Committee Chairman), General Electric Co., Nela Park, Cleveland, Ohio, "Television Studio Lighting Committee Report."

FRIDAY MORNING

J. R. Montgomery, J. R. Montgomery Engineering Co., Chicago, Ill., "Tape Transport Theory—Speed Control."

George Lewin, Signal Corps Photographic Center, Long Island City, N.Y., "Special Techniques in Magnetic Recording for Motion Pictures."

George Lewin, Signal Corps Photographic Center, Long Island City, N.Y., "Synchronous Quarter-Inch Magnetic Tape for Motion Pictures."

Leslie I. Carey and Frank Moran, Universal-International Pictures Co., Inc., Universal City, Calif., "Push-Pull Direct-Positive Recording—An Auxiliary to Magnetic Recording."

Robert Herr, Minnesota Mining and Manufacturing Co., St. Paul, Minn., "Ferrite Materials for Magnetic Heads."

FRIDAY AFTERNOON

W. W. Wetzel, B. F. Murphey and R. Herr, Minnesota Mining and Manufacturing Co., St. Paul, Minn., "The Mechanism of High-Frequency Bias in Magnetic Recording."

George W. Colburn, George W. Colburn Laboratories, Chicago, Ill., "Editing Quarter-Inch Synchronous Magnetic Tape."

E. E. Masterson, F. L. Putzrath and H. E. Roys, RCA Victor Division, Camden, N.J., "Magnetic Sound on Edge-Coated 16-Mm Film."

James A. Larsen, Academy Films, Hollywood, Calif., "Improved Kodachrome Sound Quality With Supersonic Bias Technique."

C. H. Evans and J. F. Finkle, Eastman Kodak Co., Rochester, N.Y., "Sound Track on Eastman Color Print Film."

R. T. Van Niman (Subcommittee Chairman), 4441 Indianola Ave., Indianapolis, Ind., "Report from Phototube Subcommittee of Sound Committee."

Meetings of Other Societies

American Physical Society, June 25–28, Vancouver, Canada

American Institute of Electrical Engineers, June 25–29, Toronto, Canada

Illuminating Engineering Society, Aug. 27–30, Washington, D.C.

Biological Photographic Association, 21st Annual Meeting, Sept. 12–14, Kenmore Hotel, Boston, Mass.

Theatre Equipment and Supply Manufacturers' Association (in conjunction with Theatre Equipment Dealers), Oct. 11–13, Ambassador Hotel, Los Angeles, Calif.

National Electronics Conference, Seventh Annual Conference, Oct. 22–24, Edgewater Beach Hotel, Chicago. The conference is sponsored by the American Institute of Electrical Engineers, Institute of Radio Engineers, Illinois Institute of Technology, Northwestern University and the University of Illinois, with participation by the University of Wisconsin and the Society of Motion Picture and Television Engineers.

The American Institute of Physics is holding a twentieth anniversary meeting in Chicago on October 23–27. Its member societies will hold meetings at that time as follows:

Acoustical Society of America, Oct. 23–25
Optical Society of America, Oct. 23–25
Society of Rheology, Oct. 24–26
American Physical Society, Oct 25–27
American Association of Physics Teachers, Oct. 25–27

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THROUGH the cooperation of the Library Binding Institute, an organization of binderies which specializes in binding publications into volumes, arrangements have been made to give information and assistance to Society members who want to have their JOURNALS bound. This work may be done in accordance with standards of materials and construction required for durability, service and accessibility by college, reference and public libraries. The American Library Association and the Library Binding Institute have cooperated in promulgating "Minimum Specifications for Class A Library Binding" based on research and production and performance experience.

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As Part II of this issue, there is appended a Volume Title Page with Volume Contents to go at the front of the volume when bound, and the Volume Index to go at the back.

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